PRODUCT ENGINEERING

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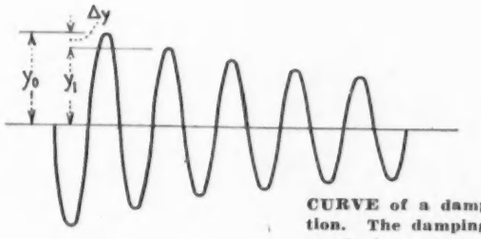


CURVE of a damped vibration. The damping constant can be found from this curve

The Damping Factor in Vibrations

By A. L. KIMBALL

Research Laboratory, General Electric Company

Noise, critical speeds, resonance, vibrational stresses, and damping are problems of basic importance in meeting the insistent demands for high-speed machines and silent operation. The damping factor, explained in this article, is the fundamental element in the solution of such problems.

PREVENTION of vibration and noise has recently come to be of such commercial importance that it is being given much study to gain a better understanding of its fundamentals and to make effective application of this knowledge.

This article will consider that part of the subject which falls under the heading of vibration damping, a term often used loosely by otherwise well informed engineers.

The technical use of the term "damping" implies energy dissipation of some sort, and therefore friction. Contrary to a common belief, vibrations cannot be damped by springs alone. Friction also must be present. It is true that prevention of vibration transmission may result from the use of pure spring supports, but this process is elastic cushioning, and not damping.

When friction, tending to resist the motion of a freely vibrating body, is applied, a steady decrease in the amplitude of the vibration takes place. The vibration is said to be damped by the applied friction. In fact, the best method of measuring the amount of damping present in the vibrating system is to observe the exact rate at which a free vibration decreases. This quantity is called the logarithmic decrement, or simply the decrement of the vibrating system. It is sufficient to say that, in general, the decrement δ is most easily found by taking the ratio $\frac{\Delta y}{y}$ as scaled from a curve of a damped vibration like that shown in the accompanying figure, Δy being the decrease in y per cycle.

This quantity has several advantages for specifying vibration damping. It is "dimensionless," that is, it is a pure numerical ratio which is the same regardless of the physical units used, such as, pounds and inches, or grams and centimeters. It is easily measured, and is also easily found from the experimental data of previous workers on this subject—of which there are many.

A knowledge of the decrement δ gives a means of finding at once the rate of vibrational energy dissipation through the use of the formula

$$\Delta W = 2\,W\delta \qquad (1)$$

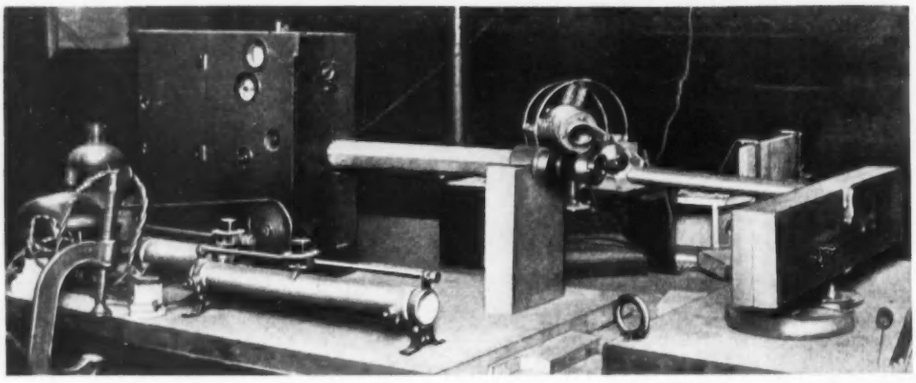
derived in this article, where

ΔW = dissipation of energy per vibration cycle
W = total vibrational energy
δ = decrement

When once δ is known it is usually a simple matter to estimate the total vibrational energy, if it is remembered that at maximum displacement the energy is all potential, and at the maximum velocity point of the swing it is all kinetic.

The above formula is a very general one. It holds for any vibrating system, no matter what mode or kind of vibration is present, provided that the force tending to restore the vibrating body to its original shape or position is proportional to the amount of the

distortion or displacement. That is, stress must be proportional to strain, which is known to be almost universally true. The formula is independent of the character of the damping of the system. Thus the damping friction may be applied internally or externally, and may be any kind whatsoever, such as air friction, liquid friction, sliding friction, or internal friction in the spring material. The damping may be found at any instant during the vibration decay, if δ is measured at that instant.



APPARATUS for photographing vibration decrement curves at ten-fold magnification

The decrement δ may vary from point to point on a vibration decrement curve, and it usually does. For "solid friction" damping, such as that produced by the friction within a spring material, δ is usually larger for large than for small amplitudes. For "coulomb friction," such as that produced by friction between surfaces pressed together, δ is larger for small amplitudes. It is a constant for all amplitudes only when the dissipation per cycle is proportional to the vibrational amplitude squared, as the total vibrational energy W must always be proportional to the square of the amplitude of vibration, if stress is proportional to strain.

Another reason why the decrement δ assumes importance in vibration prevention work is because the internal friction within all ordinary solid materials, including all metals thus far tested by the author, yield a value of δ which is independent of frequency, and approximately independent of amplitude. Therefore, when δ is once measured for a given metal at one frequency and amplitude, the dissipating power of that metal is known for vibrations of all frequencies, the higher harmonics and the lower harmonics having the same δ.

The most simple and most common way of measuring the damping constant δ of a system is to find it by measurement from a vibration decrement curve, like those illustrated. This is easy to do, and sufficiently accurate for most work.

Sometimes cases arise wherein it is easier to find ΔW, the energy dissipation per cycle, of the vibrating system directly, as when an iron bar, clamped at one end, is maintained vibrating at its resonant amplitude by a magnet. If it is found that a periodic pull of amplitude F_m produces an amplitude y_o at its point of application, it is easily shown that, at resonance,

$$\Delta W = F_m y_o$$

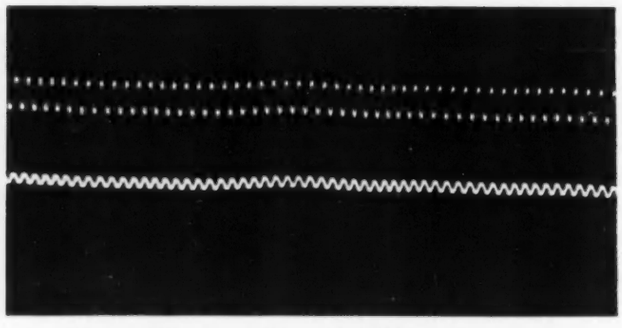
The derivation of this formula is outlined below. The amplitude of F_m can be found by weighing the pull, or it can be found electrically by measuring the flux linkage producing the pull.

A useful way of determining the damping constant resulting from friction within a solid material is to measure the amount of work required to revolve a rod of the material at a certain rate while the rod is given a deflection by a weight, as in the revolving rod fatigue test. It is by this method that the values of δ given in the table were found.

Although the method of free vibrations first mentioned gives an accurate means of measuring δ for a whole vibrating system — spring, clamps and all—it is very unreliable if the internal friction of the spring material only is being studied. Losses which cannot easily be separated, such as friction at the supports of a vibrating bar, or air friction, are almost sure to enter.

Every system or body that is maintained in steady vibration at a fixed amplitude is receiving energy at the same rate as that at which it dissipates energy through friction and other causes. If the vibration is a resonant one, that is, if the exciting force is exactly in phase with the velocity of motion in its free period, the amplitude builds up until again the energy supplied exactly equals that dissipated during each cycle. If δ is small, as it is with vibrating bodies that depend only upon internal friction of the spring material to limit their amplitude, either the resonance amplitude becomes dangerously large, or the body resonates to an extremely small periodic force.

In machinery that is susceptible to vibration, such as the wheels and buckets of steam turbines, a knowledge of δ, both that of the vibrating structure itself and that of the metal of which it is made, is an important matter. For the nickel steel tested, the table shows a value of δ of about 0.002. In a long flexible rod rigidly clamped at its base, a very small periodic force indeed, acting at its end, may produce fatigue failure, whereas in a short stout rod of high natural frequency the force has to be of considerable amplitude, a pound or more, to produce such a failure. The amplitude of motion of the short rod is small, because of its stiffness, so that for ΔW to be large enough for a fatigue failure F_m must be relatively large. Fatigue failures that occasionally occur in short, stout turbine buckets can arise only from a powerful resonant stimulus, which makes them usually fairly easy to explain.



PHOTOGRAPH of free vibrations of the turbine bucket. Upper curve, timing wave, 256 vibrations per second; lower curve, bucket vibrations, 285 per second. $\delta = 0.0015$

Most built-up frames of structural steel have a damping factor δ many times higher than that of the metal itself, the dissipation being mostly in the joints. This is also true of the stators of large electric motors.

Formula 1 may also be used in the study of means for damping the vibrations produced in foundations of machinery. It is often difficult to measure δ directly, though this sometimes can be done. W is easily estimated, this giving ΔW, the measure of the foundation vibration absorbing power. In heavy machinery, part of the energy travels, in the form of waves, into the earth and surrounding structure. For smaller machinery, elastic suspension can be used effectively to prevent the transmission of vibration and noise.

To derive the equation for the logarithmic decrement,

Values of δ for Various Materials

Material	Logarithmic Decrement δ
Rubber, 90 per cent pure	0.26
Tin, swaged	0.125
Celluloid	0.045
Maple wood	0.0224
Zinc, swaged	0.0188
Aluminum, cold rolled	0.00336
Brass, cold rolled	0.0045
Copper, cold rolled	0.00495
Tungsten, swaged	0.0162
Swedish iron, annealed	0.0075
Mild steel, cold rolled	0.0049
Molybdenum, swaged	0.00664
Nickel, cold rolled	0.00325
Nickel steel, 3½ per cent, swaged	0.00231
Monel, cold rolled	0.00134
Phosphor bronze, cold rolled	0.00036
Phosphor bronze, annealed	0.0032

consider a damped vibration as given by the following equation and shown in the first figure,

$$y = y_o\, e^{-at}\cos\, \omega t \qquad (2)$$

The logarithmic decrement δ is defined as the natural logarithm of the ratio of any two successive amplitudes of a vibration whose amplitude decreases exponentially. Equation 2 represents the curve of such a vibration.

Expressing the logarithmic decrement mathematically using Naperian logarithms:

$$\delta = \log \frac{y_o}{y_1} = \log \frac{y}{ye^{-at}} = \log\, e^{at} = \alpha T \qquad (3)$$

where T is the period of a complete vibration.

Another useful way of expressing δ is derived by making use of the logarithmic series

$$\log x = (x - 1) - \tfrac{1}{2}\,(x - 1)^2 + \ldots\ldots \qquad (4)$$

For any amplitude y

$$\delta = \log\left(\frac{y - \Delta y}{y}\right)$$

PHOTOGRAPHIC record showing quick damping of a concrete tuning fork. Ten vibrations per second, and $\delta = 0.075$

(see equation 2), where Δy represents the decrease of y per cycle, as shown in the first figure. Substituting in equation 4, $\frac{y - \Delta y}{y}$ for x, we get: $\delta = \frac{\Delta y}{y}$ (5)

where all terms of the series except the first are dropped since they are relatively small in most cases.

The latter expression for δ is useful. By its means δ can be found at once by a simple measurement from a graph or a photograph of the damped vibration, such as shown in the illustrations.

When δ is known, the amount of energy dissipated per cycle, ΔW, can be found as follows:

The total vibrational energy W, at some time t is:

$$W = ky^2$$

since it equals the maximum potential energy of the system. The total vibrational energy one cycle later equals

$$k\,(y - \Delta y)^2 = W - \Delta W$$

Subtracting the latter from the former to find W

$$\Delta W = k\,(y^2 - y^2 + 2y\Delta y - \Delta y^2) - 2\,ky\Delta y$$

where $-\Delta y^2$ is dropped as being negligible. Therefore,

$$\Delta\,\frac{W}{W} = \frac{2\,ky\Delta y}{ky^2} = 2\,\frac{\Delta y}{y} = 2\delta$$

$$\Delta W = 2W\delta \qquad (6)$$

In words, this equation expresses the relationship that the energy dissipation per cycle of a vibration whose amplitude decreases exponentially with time is equal to the total energy of the vibration at the time in question multiplied by twice the logarithmic decrement.

To derive an equation for the energy supplied per cycle from periodic force:

Let motion $= y = y_o \sin \omega t$

Velocity $= V = y_o\omega \cos\, \omega t$

Force $= F = F_o + F_1 \cos\, \omega t + F_2 \cos\, 2\,\omega t + \ldots\ldots$

Power = Force times velocity

$$= F_o y_o \omega \cos\, \omega t + F_1 y_o\, \omega\, cos^2\, \omega\, t + F_2 y_o \omega \cos\, \omega t \cos\, 2\,\omega t + \ldots\ldots$$

Integrating over one cycle from

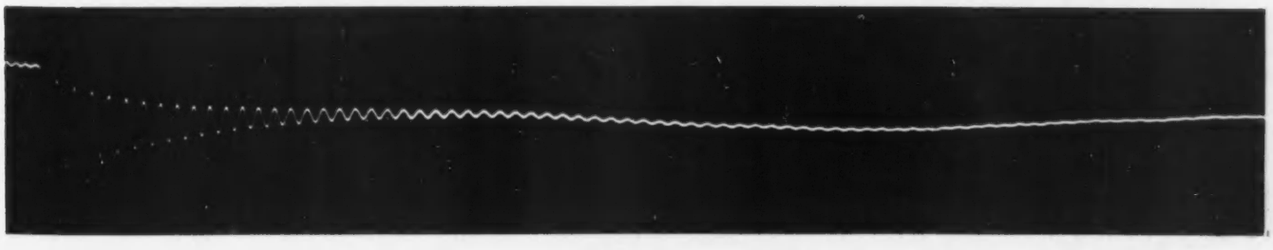
$$t = 0 \text{ to } t = \frac{2\pi}{\omega}$$

$$\text{Energy per cycle} = \Delta W = \int_o^{\frac{2\pi}{\omega}} F_o y_o \omega \cos\, \omega t\, dt + \int_o^{\frac{2\pi}{\omega}} F_1 y_o \omega \cos^2\, \omega t\, dt + \ldots\ldots$$

$$= F_1 y_o \pi = F_m y_o \pi$$

where F_1 is replaced by F_m

It should be noted that at resonance, force and velocity are in phase.



Vibration, Corrosion, factors in CENTRIFUGAL EXTRACTOR DESIGN

By C. F. MEYER

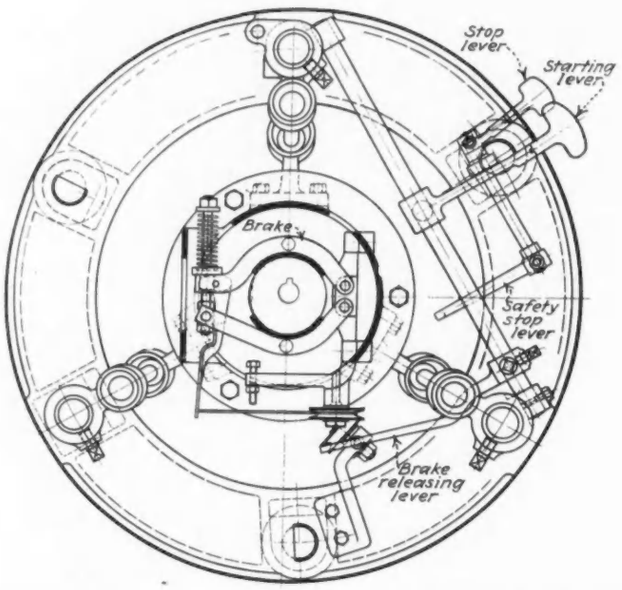
Engineering Department, Textile Machine Works

PRINCIPAL causes of accidents inherent or incidental to the working of extractors are: Bursting of the drums or baskets because of excessive speeds of rotation, weakness of construction, or corrosion of the metal; and excessively wide oscillations of the basket. The latter originate mostly in the vibrations characteristic of high-speed extractors.

Ever since centrifugal extractors were first used, it has been the goal of the designers of these machines to eliminate, or at least to alleviate, these highly objectionable vibrations which develop in an extractor running at high speed. They are not only of a very destructive nature to the bearings, supports, and general structure of the apparatus, but also are extremely dangerous, since the enormous forces confined in the rotating basket may, at any moment, cause an accident. It is also to be considered that the noise and pounding, which are the audible expressions of the ever present menace of vibrational excess, have a strong psychological effect upon the operator.

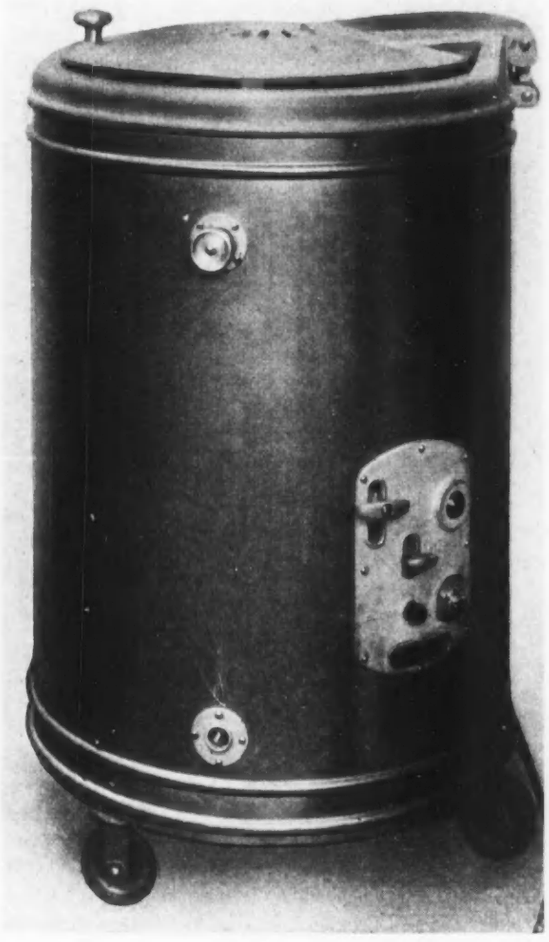
The extractor described here not only balances itself when the basket is unevenly loaded, but also absorbs vibrations entirely. So free of vibration is this machine, that it is not necessary to bolt it down. It is mounted on casters, easy to handle and operate, smooth running and noiseless.

It is a small machine of the underdriven type, having a basket 18 in. inside diameter, and revolving at a speed of 1,800 r.p.m. This is equivalent to a peripheral speed of 142 ft. per sec. The cast iron base is provided with ball-bearing casters made of phosphor bronze in order to resist corrosion. Three vertical pipes carrying brackets at their upper ends are screwed into the base and secured with headless setscrews. The brackets have spherical bearing seats into which fit the steel ball ends of freely swinging steel supporting rods. A number of rubber cushioning rings are fastened by nuts and locknuts to the lower ends of these rods. Radially extending motor brackets, fastened to the specially constructed upper motor shield, rest loosely on the rubber rings. This permits the motor, and the entire inner mechanism connected with it, to swing in an essentially horizontal plane. This design prevents the building up of any vibrations, which is extremely



PRESSING DOWN the starting lever releases the brake. Oscillation of the basket will move the safety arm, releasing the catch holding the starting lever in running position

Safety



A COMPACTLY ARRANGED panel contains start lever, stop lever, current tell-tale, push contact for power cord, motor switch and a terminal box for all Alemite cups

important, since it is impossible in such a machine to check vibrations after they have once commenced to develop.

The point of suspension of the balls, the length of the rods, the number, size, and quality of the rubber cushioning rings, and the location of the motor shield brackets must all be in a definitely determined relation to each other and to the center of gravity of the inner self-centering structure, as well as to the point of support of the basket and its plane of gravity. The exact proportions of the members of this linkage in order that the rotating shaft and motor mechanism may seek its dynamic axis of rotation, are determined experimentally. The movements of the suspended members must be in an essentially horizontal plane.

Bolted to the top flange of the motor shield and swinging with it, is a cast-iron housing which contains and protects the brake mechanism. To this brake housing is fastened the cast-iron upright in which is mounted the radial and thrust ball bearings that carry the vertical shaft made of "stainless" steel. A steel ball, fastened to the upper end of this shaft, fits into the socket of the extractor basket in such a way that the latter is free to rock in any direction. It is obvious that the basket, or bowl, in addition to this rocking movement, swings with the inner mechanism. The basket is loosely coupled to the shaft by means of a pin fitted into a slot in the socket. The bowl itself is made of cast bronze, finished all over. A balancing rib, located in the horizontal plane passing through the center of gravity of the basket, is cast on its outer surface. The basket is perforated in such a way as to obtain the best balance between extracting efficiency and resistance to centrifugal force. The inside surface of the basket has a "silk finish," that is, it is absolutely smooth and perfectly polished.

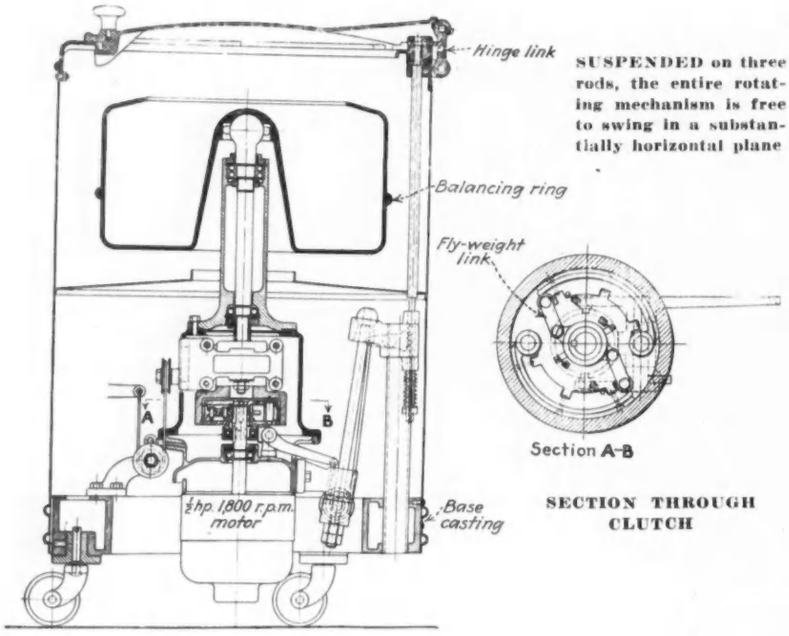
The outer shell, which is of Monel metal, Bohnalite, or other corrosion-resisting material, is of such diameter that the annular air space between the basket and the outer shell will not be too small. Confined air, when carried around with the rapidly revolving basket, may build up a cushion of compressed air which would cause the basket to rock and rebound dangerously. The radial clearance between the basket and shell should not be less than 15 per cent of the diameter of the basket. As an additional precaution, there are narrow openings between the cover and the metal ring on which it rests, allowing air to escape freely.

The lid or cover swings about a hinged link, as shown in the section view of the machine. It will be seen that the cover may thus be swung about the hinged link, and also, when closed, be pulled forward so that the lug at the cover knob slides under the top ring and locks the cover in the closed position. It is necessary to push the cover back before it can be swung open.

It is important in machines of this class to prevent access to the interior of the extractor when the machine is being driven, because of the danger of getting caught in the rotating parts. For the same reason, it must be made impossible to set the basket of an extractor into power-driven rotation while the cover of the extractor is open. This safety feature is accomplished in the manner as described below.

The outer shell of the centrifugal clutch is fastened rigidly to the shaft that rotates the extractor basket. The inner driven member of the clutch is keyed to the upper end of the motor shaft. The two shafts are in axial alignment, but not connected with each other. Two arcuate shaped phosphor-bronze fly weights, each weighing about 7½ oz., are pivoted to the inner member of the clutch. The outer surfaces of these weights are covered with leather, asbestos, or other friction material, and engage the inner surface of the outer shell of the clutch when the fly weights are thrown outwardly by centrifugal force, thus transmitting the drive to the basket. The centrifugal clutch insures a gradual increase of load on the motor when starting.

The outer free ends of the fly weights are connected to a ring which is free to rotate, and the outward movement of the fly weights turns



SUSPENDED on three rods, the entire rotating mechanism is free to swing in a substantially horizontal plane

SECTION THROUGH CLUTCH

this ring. The lower surface of the ring has cam projections in contact with another ring located below it and splined to the motor shaft to permit sliding on it. This lower ring, shown in the section view, is located between the clutch and the motor shield. A lever, pivoted on the housing, is pinned to the ring. The outward movement of the fly weights imparts a downward motion to the sliding ring and thus rotates the lever, moving its outer end upward. As shown in the close-up view of the mechanism, a bronze cable is fastened to the end of the lever and runs over a pulley, thus transmitting the motion of the lever to the extending arm of a spur-gear sector. This sector is in mesh with a rack pinned to a vertical slide rod, normally held in its lowest position by a spring. Adjustment of this compression spring adjusts the action of the clutch fly weights. The movement of the lever forces the vertical rod upwards, and the upper end of the rod goes into a hole in the cover of the machine. The hole in the cover is in alignment with the rod only when the cover is pushed forward and in the locked position, making it impossible to open the cover while the extractor is running.

When the cover is open, a small steel plate mounted in a guide slot and connected to the hinge link of the cover, as shown in the section view, is pushed forward and closes the opening, thus preventing the vertical rod from being pushed upwards. The arrest of this motion also prevents motion of the connected cable and lever, and in turn, the fly weights in the clutch. In consequence, the motor shaft cannot drive the basket shaft, and the latter will not revolve.

Another important feature is the brake mechanism shown in the cross-sectional plan view. The brake is always in a closed position while the power is off the motor. When the starting lever is pressed downwards it rotates the connected shaft and lever and by means of a bronze cable the movement is transmitted to the brake lever, opening the brake against the action of the springs.

MOTOR brackets, suspension rods, and safety mechanism

Continued movement of the starting lever closes the motor switch. When it is pressed all the way down, the starting lever is engaged by a catch mounted on the shaft of the stop lever. To stop the machine, the stop lever is lifted up, releasing the catch. This shuts off the power and throws on the brake.

A safety stop lever is also mounted on the stop lever shaft. If for any reason the oscillations of the revolving basket should exceed the safe limit, the bottom of the basket strikes the end of this safety lever, and thus releases the catch holding the starting lever in running position.

The operating panel, as shown in the picture, contains in addition to starting and stop levers, a push contact for the power cord, the push button for the electric switch, an open terminal box for the Alemite cups, and a "bulls eye" or warning lamp which shows red when the current is on.

All bearings, joints, and moving parts are lubricated by a piped Alemite system. The pipes all lead to the terminal box in the panel.

A high torque repulsion induction motor, ½ hp., 1,800 r.p.m., of a design developed by the General Electric Company, is used. The motor is water tight, and is fan cooled. It has SKF bearings, the thrust bearing supporting the rotor being a No. 204 deep groove bearing of a rated thrust capacity of approximately 70 lb. Since the weight of the rotor is only 15 lb., this gives a factor of safety of almost 5, which factor was carried through in all other calculations for this extractor.

The basket weighs about 52 lb., and carries a maximum load of 40 lb., making 92 lb. total. The upper end of the basket shaft is carried in a double-row Fafnir bearing having a radial and thrust capacity of 748 lb. at 2,000 r.p.m. A single row bearing having a radial load capacity of 148 lb. at 2,000 r.p.m. is used at the lower end of the basket shaft. A good grease seal is one of the essential requirements of the bearings used. Oilless bushings of various types were tried, but were found to be unsuitable for this type of work.

The lid and the ring on which it rests are both of aluminum and coated with banana oil. In the center of the cover are a number of oblong slots arranged in a starlike formation, to give a circulation of dry air in and around the revolving basket, thus contributing to the high efficiency of the extractor.

Securing Mechanical Variations With Interchangeable Units

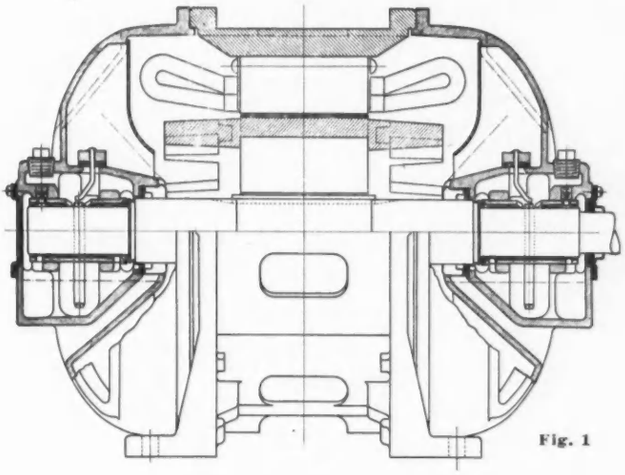


Fig. 1

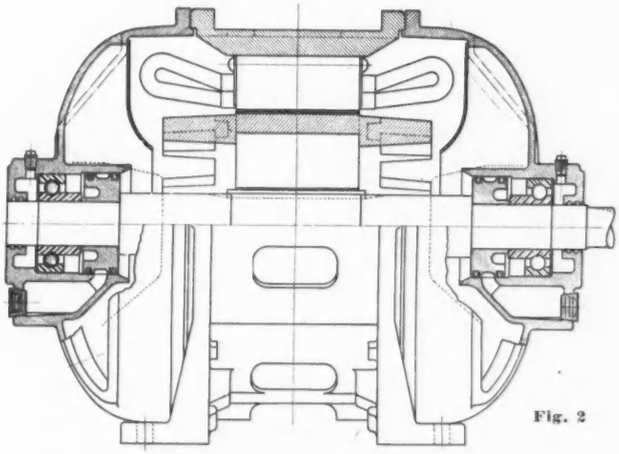


Fig. 2

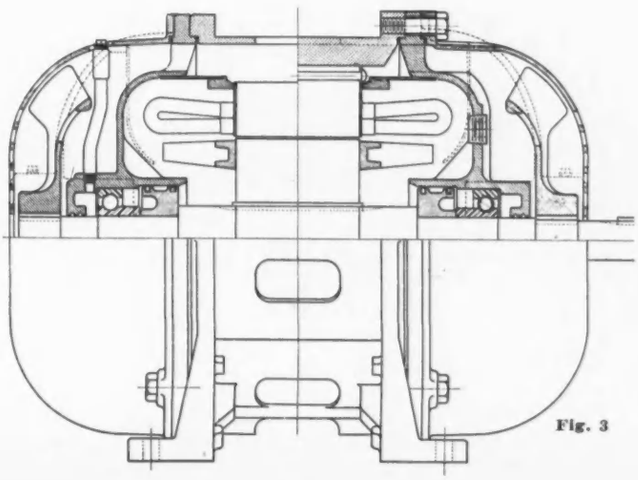


Fig. 3

By J. L. BROWN

Industrial Motors Engineering Department, Westinghouse Electric & Manufacturing Company

ADAPTED from a paper presented at the Fourth National Machine Shop Practice Meeting of the A.S.M.E., this article describes how electric motors, or any assembled product, may be designed to make available a variety of forms by means of interchangeable details. Forthcoming numbers of Product Engineering will contain articles presenting specific data and information required by the designing engineer in selecting the motor of proper type and rating and of suitable mechanical design.

DIFFERENT mechanical types of electric motors are occasioned by requirements of service. The horizontal, open-ventilated motor is most widely used, but there are many others differing in the relation of the shaft to the horizontal plane, the measure and method of enclosure, and the method of attachment to the supporting structure. Hence, there are both horizontal and vertical motors, open, totally-closed, enclosed-ventilated, force-ventilated, self-ventilated, explosion-proof, water-tight, floor-mounted, end-mounted, built-in, overhung, and many other types. In addition, there are variations in type of bearings, and also variations in facilities for mounting accessories, such as brakes.

In Fig. 1 is shown a longitudinal sectional assembly of a horizontal, open, sealed-sleeve bearing, squirrel-cage induction motor. By removing the end brackets, shown in dotted outline in Fig. 2, and replacing them and the shaft with similar parts adapted to ball bearings, as indicated in full lines in Fig. 2, the motor becomes a ball-bearing type without change in mounting dimensions or in length.

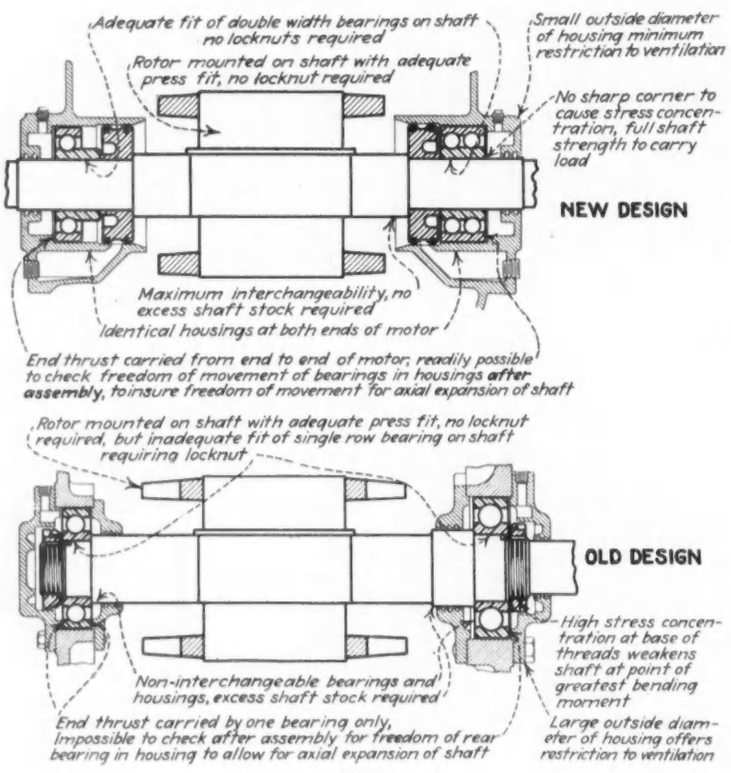

Adequate fit of double width bearings on shaft no locknuts required
Rotor mounted on shaft with adequate press fit, no locknut required
Small outside diameter of housing minimum restriction to ventilation
No sharp corner to cause stress concentration, full shaft strength to carry load
NEW DESIGN
Maximum interchangeability, no excess shaft stock required
Identical housings at both ends of motor
End thrust carried from end to end of motor, readily possible to check freedom of movement of bearings in housings after assembly, to insure freedom of movement for axial expansion of shaft
Rotor mounted on shaft with adequate press fit, no locknut required, but inadequate fit of single row bearing on shaft requiring locknut
OLD DESIGN
High stress concentration at base of threads weakens shaft at point of greatest bending moment
Non-interchangeable bearings and housings, excess shaft stock required
End thrust carried by one bearing only, Impossible to check after assembly for freedom of rear bearing in housing to allow for axial expansion of shaft
Large outside diameter of housing offers restriction to ventilation

Fig. 4

Referring to Fig. 3, it will be clear that replacement of the brackets and shaft, and the addition of other accessories, will result in an enclosed, motor in which the windings are completely protected from destructive elements permeating the surrounding atmosphere, with ventilation effected by blowing air on the exposed portions of the enclosure. Here again, the transformation is accomplished without a change in either mounting or over all dimensions, and by using the same frame and electrical parts as in the original open, horizontal, sleeve - bearing motor.

In a similar way other types can be produced. In this manner it is possible to build from a limited number of parts any one of many different types of motors, or to convert any type into any other type at minimum cost. Many of the variations in type are accomplished by closure or partial closure either with or without gaskets, of the hand-hole openings in the end brackets of the open motor.

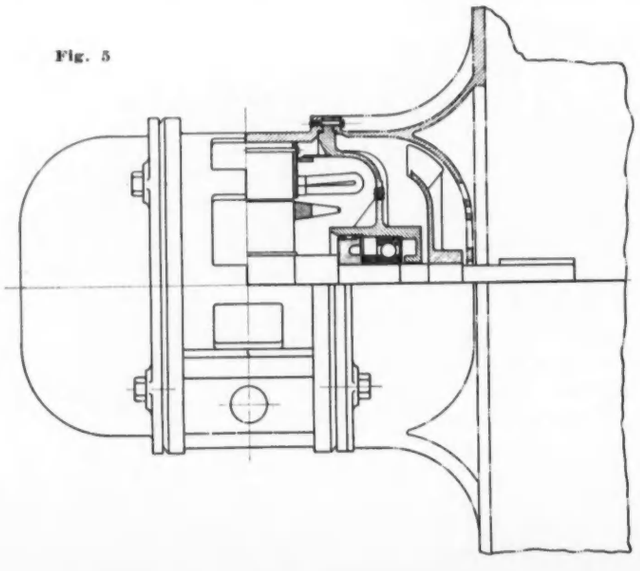
In the mechanical variations which must be produced it is desirable to use identically the same parts wherever possible. Parts that must be different from others in some respects should be designed sufficiently similar in form and size so that the same tools can be used, with as little change in adjustment as possible, for casting and machining.

Of recent years ball and roller bearings have gained favor in some quarters for motor application. The great variety of types and makes of these bearings, each with its following of proponents among users, has introduced many problems in their application to motors, and has tended toward diversity of mounting, involving expense and delay in delivery of the apparatus to the user.

Ball bearings are made in single and double width by almost all manufacturers. One manufacturer has an intermediate standard. Roller bearings are made to all three standards by various manufacturers, and some differ only a small amount from the standard. Most ball and roller bearings have their outside diameters and bores in millimeters. Others are made in inch dimensions. This great diversity is one of the factors in making an interchangeable mounting difficult of achievement. The width of the double-row ball-bearing is adopted as standard in the designs of mountings shown here. Single-row bearings are provided with an inner race extended on one side to give a total width equal to that of the double-row bearing. All makes of bearing can be obtained in the double-row width, thus making it relatively easy to serve customers with their preferred brand.

THE greatest bearing load occurs at the shaft-extension end of the motor, the load at the opposite end being relatively light. To suit this disparity in loading, it has been customary to use a large bearing at the shaft-extension end and a small one at the opposite end. This arrangement, however, results in two different end brackets for a squirrel cage induction motor that is otherwise symmetrical. In the new design shown here, this difficulty is overcome. At the same time the bearing capacity is adapted to its load by employing a large-capacity double-row bearing at the pinion end, while at the other end, where the load is light, a relatively lower-capacity interchangeable single-row bearing with wide inner race is used. In Fig. 4

Fig. 5



the relative simplicity of the new design as compared with the old, is made evident.

The internal parts of electric motors must be very carefully designed, but it is also important that the attachment of the motor to the foundation or driven machine receive careful consideration. Interchangeability from this standpoint has suffered neglect in the past, and is a feature that has been the subject of much discussion.

IMPORTANT dimensions affecting interchangeability of standard horizontal motors are the shaft and keyway dimensions, the distance from the face line of the pinion or pulley to the first pair of holding-down bolts, the distance between the first and second pairs of holding-down bolts, the distance measured at right angles to the shaft, between holding-down bolts, the diameter of holding-down bolts, and the height of the shaft centerline above the bottom of the motor feet.

Horizontal motors having the standard mounting arrangement are usually attached to a horizontal support below the motor. If attached to a wall or ceiling, the motor must be placed with the shaft in a horizontal position. Oil-lubricated motors may be tilted up to a maximum angle of 10 or 15 deg. between the shaft and the horizontal. For greater inclination, up to the vertical position, grease-lubricated motors are commonly used. However, for vertical operation or with inclination from the vertical not exceeding 15 deg., it is possible to obtain motors having specially designed oil-lubricated bearing assemblies.

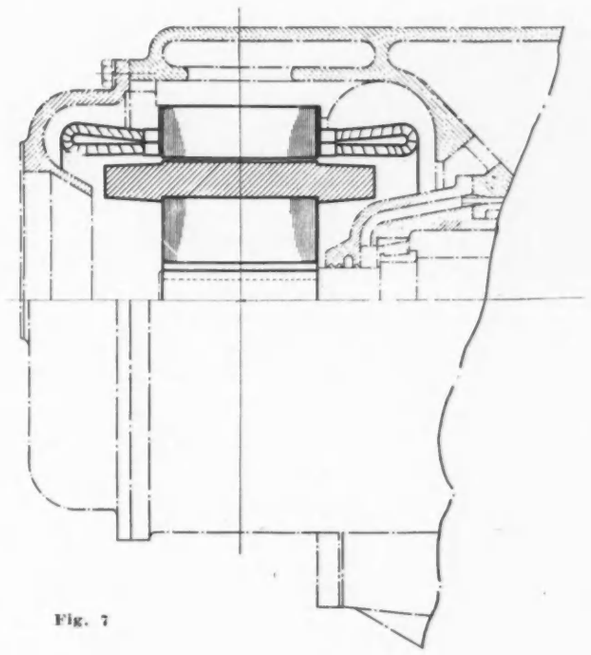


Fig. 7

Sometimes it is desired to mount motors, either horizontally or vertically, in more intimate association with the driven machine than is possible with the more widely used standard mountings. For vertical mounting, the driven machine may be designed to furnish the vertical base, bosses directly on the end brackets of the motor being employed as means for attachment. It will be seen that this provision incorporated in the brackets does not introduce interference with machining operations on brackets that do not have these bosses. Also, these bosses on standard foot-mounted horizontal motors may be useful in mounting brakes, gear guards, or other accessories.

In Fig. 5 is shown an intimate mounting in which a portion of the driven machine is designed to serve as the fan or blower casing of the enclosed-ventilated motor. The motor is supported by bolting the bracket to the frame ring, thereby obtaining a neat and compact arrangement. For open motors, the motor end bracket is sometimes incorporated in the design of the driven machine, winding clearances and air guides being provided as required. The so-called "three-quarters" motor, as illustrated in Fig. 6, is procurable for such installations.

When the shaft of the driven machine is large and rigid, it may possibly be extended and the motor rotor mounted on the shaft extension. The outboard bearing would be omitted. The wound-stator core may be supported in an extension of the frame of the driven machine. Such a design gives compactness and simplicity. The motor parts furnished by the manufacturer are illustrated in Fig. 7. The wound stator without frame, shown in dotted outline, is a self-contained unit and can be pressed readily into any frame having the requisite machined fits, clearances for windings, and passages for ventilating air.

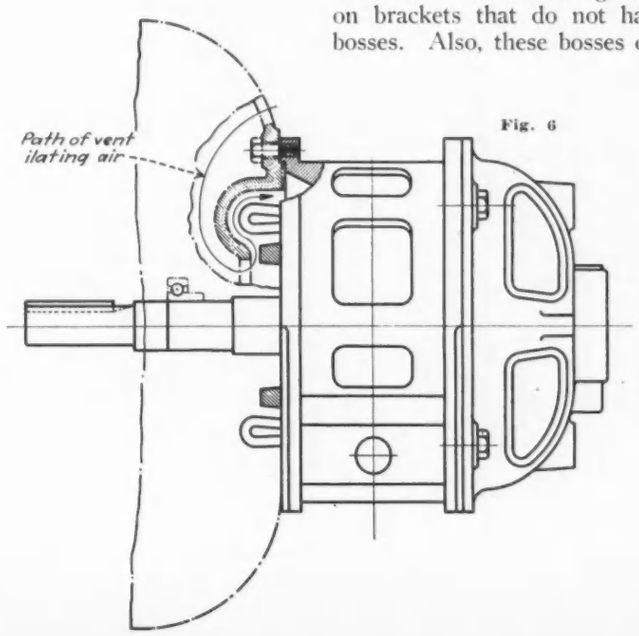


Fig. 6

INDUSTRIAL WHEELS ARE SPECIALIZED UNITS

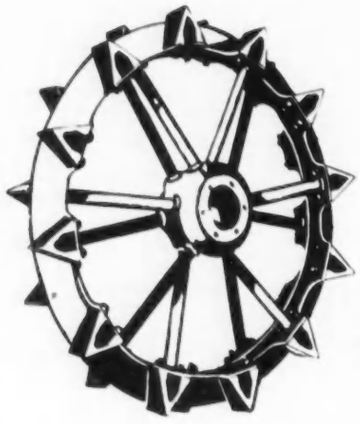
By W. F. HEESCH

General Manager, French & Hecht, Inc.

CONTINUED development of wheeled machinery in agriculture and construction work, and in other industries is constantly placing new requirements on wheel design—heavier loads, higher speeds, and new applications of wheels and machinery have made wheel design a highly specialized branch of engineering. In general, wheels of today are being made much stronger than in the past, and this added strength is being gained by more careful use of materials, better materials, improved design of wheels, and advanced knowledge of wheel mechanics.

Because of changing operating conditions and newer applications of power and speed, particularly through the use of the tractor, new types of wheels must be created to meet the new demands. There are more than 6,000 wheel types now on the market, the chief variation being in the style of hub. While the agricultural implement industry calls for the largest variety of wheels, industrial machines increasingly require a vast assortment. Fire extinguishers, barrel lifts, concrete mixers, lumber dollies, wheelbarrows, and baggage trucks fall within this latter classification. Road building and maintaining equipment is another field where wheels must be supplied to meet the particular requirements. Also, there is the automotive group represented by trucks and tractors. Passenger car wheel design is a field in itself and will not be considered in this article.

IT IS POSSIBLE to increase the tractive effort by dual treads. An adapter form of hub is employed for the outer wheel



OPEN-TIRE wheel with spuds for operation in sticky soil

Early wheels had wooden or cast-iron hubs, wooden spokes, and a wooden rim bound by an iron tire that was shrunk in position. Today, on most types of industrial and agricultural equipment, wheels are made entirely of metal. They are of four general types: (1) wheels with spokes cast in the hub, (2) wheels with spokes screwed in the hub and fastened with locknuts, (3) wheels with spokes fastened to the flange of the hub and to the flange of the tire by rivets, and (4) wheels in which the spokes, while hot, are forged into the hubs, forming heads on the inside and shoulders on the outside and producing spoke fastenings very similar to a boiler rivet. The spokes are headed and shouldered into the tire and are usually in a trussed position.

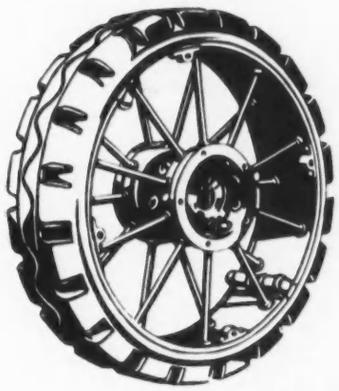
In the case of the first type, the objection is that not all of the spokes cast tight; spokes tightened by locknuts have a tendency to bear on one side only, and those riveted are under a shearing strain which is objectionable.

It is particularly important that the tension in the spokes be uniform, which in the final analysis means that they shall be of equal length. In the hot-forged type, the spoke has a shoulder where it meets the inside of the rim, the outside end being riveted over. Because of the shoulder construction the spokes are uniform in length; hence, when pulled taut by the riveting operation all are in equal tension. Wheels that have spokes in unequal tension lack considerable of their theoretical strength under ideal conditions. The position of the spokes, as well as their number, and size, also has an important bearing upon the strength of the wheel and will be discussed in detail further in the article. Likewise, questions of side strain, torque, and weight load

all must be very carefully considered for each particular application.

Hubs are made in many materials, including cast iron, cast steel, seamless steel tubing, and malleable iron, the choice of each material being dictated by the particular condition. For example, in a tractor wheel driven by a splined live axle, a high-grade gray-iron hub is most suitable. Similarly in road graders, where anti-friction bearings are frequently used, gray iron is the most suitable material as it can be most readily machined to the close bearing fits necessary. Cast steel is employed where weight is important and where excessive strains are encountered, such as in the case of heavy-duty trucks that often are operated at high speeds over rough roads.

Frequently, it is desirable to have a removable bushing, particularly where there is a driving part on this bushing that is subject to wear, such as in the case of ratchet drives found in some types of agricultural equipment



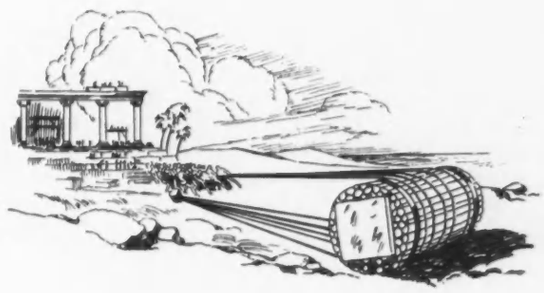
INCREASED resiliency, larger contact area, and less slippage result from the use of this zero-pressure, hollow center hard rubber tire, developed recently for tractor treads

CROSS STRAPS make possible the attachment of driving devices, such as an internal ring gear

where the drive power is taken from the wheel. For such a condition the drive member is usually made of cast or malleable iron, and the hub is of seamless steel tubing rolled to shape. Malleable iron is used for hubs, but has largely been replaced by cast steel. However, when there are peculiar shapes and other limitations necessary to meet fixed conditions, a design is sometimes necessitated that is best adapted to malleable iron.

Seamless tubing is light and strong, and can be rolled to various shapes without additional machining operations. For this reason it is used in connection with a cast-iron bushing for any type of vehicle where light and strong wheels are desired at a low unit cost.

Another variable in wheel design is the number, size, and position of the spokes. Four general shapes are used: round, oval, rectangular, and semi-diamond shape, that is, in the form of a flat diamond with truncated



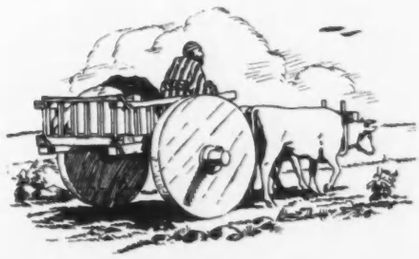
points on the major axis. The round spoke is the universal type since it is suited to take the stresses in any direction, namely, the weight load, side strain, and the torque load, each acting in the three principal planes. For agricultural equipment to be used in hilly country, where side strain becomes quite important, the oval spoke is used, mounted with its axis parallel to the wheel axle. The modified diamond type can also be used in the same location. Both sections are light but stiff in the direction of load and hence are ideal for this work. When the torque load is high, particularly when it is in excess of the vertical or carrying load, at the hub, the rectangular section is employed. An example of this is in tractor wheels. In this particular application, the major axis of the rectangle is at right angles to the axis of the wheel so as to give the greatest resistance against torque and at the same time the lightest weight of material.

The strength of such a wheel against torsion is illustrated by the example of a wheel 48 in. in diameter which was subjected to a torque of the drive shaft, which was splined in the hub, indicating that the strength of the spokes was in excess of any twisting load that could be imposed through the drive shaft.

Compared with wire wheels used on passenger cars, the tension stresses in these spokes are relatively small because of the large areas. Also, much dependence is put upon the uniformity of tension in the spokes rather than in the selection of high-tension materials. Obviously, the tension is always in excess of any possible weight load so that no compression stresses could be developed on the spokes when in their lower position.

For tractor front wheels, it would seem that a round spoke would be most practical because of the swivel or caster effect, but actually an oval spoke mounted with its major axis at 60 deg. to the axis of the wheel is what is commonly employed. By using a double row of spokes arranged in the form of a truss, this arrangement works out very satisfactorily.

Another factor to be considered is the distance between spoke chambers of the hub, and this depends largely upon the relative amount of side thrust to be encountered. A factor governing the number and size of the spokes is the section of the tire: obviously, a



stiff tire needs less spokes to support it than a more flexible one.

In general, two kinds of materials are used for spokes —low-carbon and high-carbon steel. Where the vehicle is to be run over hard-surfaced roads, high-carbon steel would be impractical because of fatigue failure. For vehicles to be operated over solid ground or on soft roads, however, high-carbon steel is practical because it gives greater strength for the same weight of metal. producing a stiff, light-weight wheel that is capable of withstanding considerable twisting strains.

Rims are usually made of basic open-hearth steel with a carbon content ranging from 0.15 to 0.25 per cent. They vary in section from $2\times\frac{1}{8}$ in. up to $18\times\frac{5}{8}$ in. A wheel made of the latter section and 80 in. in diameter weighs about 700 lb.; one made of the smallest material and 14 in. in diameter weighs one-tenth of this. Wheels are available, of course, that are much lighter than this. For example, a 26-in. spreader wheel weighs less than 40 lb. Rims or tires are made in several forms such as flat, concave, convex, groove and flange, or a combination of several of these. Where easy swiveling movement is desired, the concave type is best suited, whereas in agricultural work where it is desired to follow a furrow, or in road work to offset the side strain from a scraper, the convex type is preferred because it digs in and holds its position. Flanges are formed in the rims to strengthen the section without any increase in weight. Grooves accomplish the same purpose, and also provide a channel for the rivet head of the spokes. Such a construction is particularly desirable where the wheel is to be operated over a hard-surfaced road and where the rivets would otherwise be damaged.

RIMS are usually formed from flat stock rolled into a circle and butt welded, generally electrically. When properly performed, the strength of the weld is equal to that of the rest of the rim, hence the designer may consider the material as homogeneous throughout.

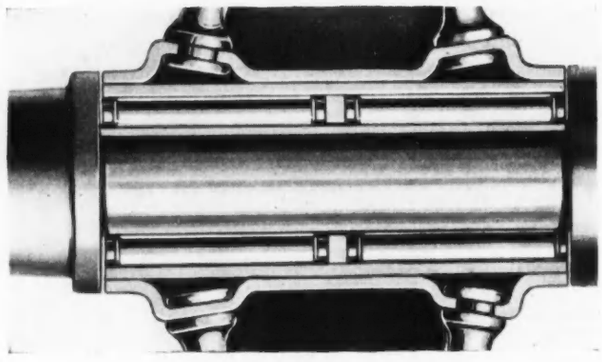
In order to increase the draw-bar pull compared with the weight on the tread, resort is made to traction spuds or cleats attached to the face of the tire. Their number and size depends very largely upon the character of the soil and topography worked. A number of sizes and shapes have been developed to meet the changing conditions of the soil. For example, for the sticky Texas "gumbo" that will build up on a solid-face wheel there has been developed the so-called open-face wheel. Such a wheel is usually formed by a pair of annular rings of rectangular section, the major axis being radial. Almost any type of spud can then be bolted to these open rims.

Where solid rubber tires are to be applied to tractor wheels, the rim is generally of the expansion type; that is, it is split in two halves, with expanding wedge devices that can be bolted in place after the rubber tire, which is molded on an auxiliary steel rim, is in position. This construction allows changes to be made on the farm where a hydraulic press is not available.

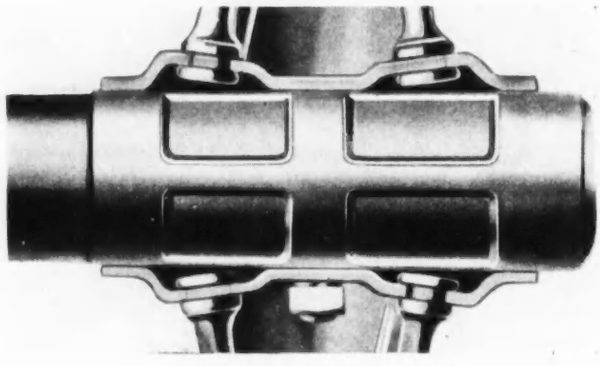
Until the general adoption of the hard road, little or no attention was paid to the material from which wheels were constructed, or more particularly to the material from which tires were constructed. But steel-tired wheels equipped with grousers destroy these expensive roads, and thus the rubber-tired wheels have come into being.

Solid rubber or pneumatic tires are now commonly used on machines intended for transport on highways. Recently, rubber-tired wheels have been used on tractors, highway mowers, hay balers, shredders, shellers, trailers, and pumping units.

At first hand, it would not appear that rubber tires would be warranted on a concrete mixer, but one look at one of these machines trailing behind a truck at 30 miles an hour, quickly convinces the engineer of the practicability of using rubber tires on such a piece of equipment. To cite another instance, a farmer once purchased a walking cultivator in town and hauled it



ROLLER BEARING HUB



HUB OF SEAMLESS TUBING

home behind his car. Because the wheels on this machine had steel rims, they were ruined even before he had put it in operation, because of the heavy hammering on the hard pavement.

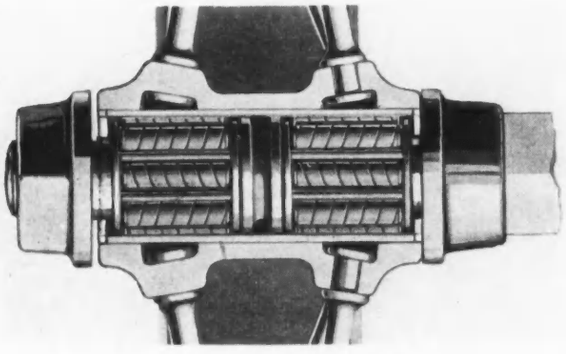
ORDINARY trailers for automobile trucks and industrial tractors quite generally have been equipped with rubber tires, usually of the solid type until recently. There is now, however, a marked tendency toward tires that are more resilient than solid rubber. This demand has been met by the pneumatic or the semi-pneumatic tires. Besides producing a cushioning effect on the implement itself, which is of some advantage, there is also available an increase in comfort to the operator—a fact that is beginning to be considered for the first time. Such instances as these indicate some of the many factors that have to be taken into account by the designer. Wheel engineering, in fact, involves endless research and study of a number of factors and conditions that affect each individual application: to make a wheel that is mechanically correct for each operation is the task of a specialist.

Equipment that is not used on hard roads, such as agricultural machinery in general, is also going through a pronounced change in design because of the almost universal use of the tractor with its element of speed in operation. Today, plowing an acre an hour is not

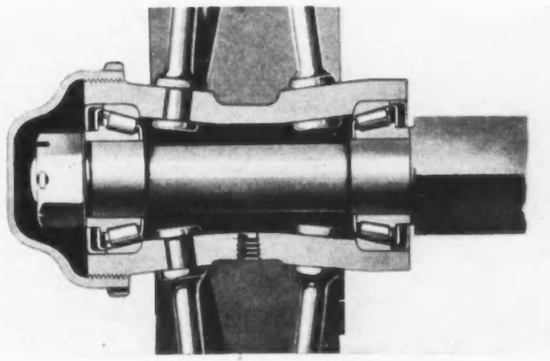
uncommon, and power cultivation which was once a dream is now a reality. The same is true for road-making machinery which has increased its power and size in the last few years to a considerable degree.

Study has been made by tire manufacturers as to the proper size, shape, and general proportion of tires with the object of obtaining a tire that will give maximum tractive effort and have the minimum weight, thus leaving the bulk of the tractor power for the "pay load." In the past, one method of increasing the draw-bar pull was to add weight to the wheels, usually in the form of a large cast-iron disk which was clamped to the spokes, but this did not effect a practical solution. Recent tests have shown that increasing the width of the tire and proportioning the diameter so as to get the greatest amount of surface contact is the most efficient method.

The pneumatic tire fulfills these conditions to a certain extent, but its chief drawback for trailer or road machinery is the danger of puncture. Aside from this, pneumatic tires that are large enough for tractor wheels are usually much oversize in carrying capacity and needless expense is involved. The latest solution to this problem is the "zero pressure," or hollow center, hard rubber tire that is puncture proof and is more resilient than the solid rubber tire. With these tires, draw-bar pull almost equal to the load has been obtained.



HYATT BEARING HUB



TIMKEN EQUIPPED HUB

Wheels must be designed for the particular conditions under which they will be required to serve. The hub, spokes, and rim must each perform their functions properly and satisfactorily. A few illustrative examples of typical designs have been described, but it must be recognized that there are numberless variations in the design of industrial wheels.

Books for Engineers

TEXTBOOK OF THE MATERIALS OF ENGINEERING. *By Herbert F. Moore, research professor of engineering materials, University of Illinois. 409 pages, 6x9 in. Cloth board covers. Indexed. Published by the McGraw-Hill Book Company, 370 Seventh Ave., New York, N. Y. Price $4.*

THIS is the fourth revision to bring this well-known textbook up to date with progress in research and testing of materials. Several chapters have been largely rewritten, and values for physical properties have been revised throughout the book. Descriptions of recent types of testing machines are added, and recent specifications from the A.S.T.M. are included. The present revision of the book should not only enable it to retain its position as a standard text for students, but should recommend it to engineers who are in need of a book for review on the fundamentals of engineering materials.

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MAC RAE'S BLUE BOOK AND HENDRICKS' COMMERCIAL REGISTER. THIRTY-EIGHTH ANNUAL EDITION. *3,310 pages, 8½x11 in. Cloth board covers. Published by Mac Rae's Blue Book Company, Chicago, Ill., and New York, N. Y. Price $15.*

THIS year's edition of the Mac Rae Blue Book contains a 265-page alphabetical list of important manufacturers, producers and wholesalers. Following comes the main "Classified Material Section" of 2,140 pages, and a 207-page "Trade Name Section." Also included are a "Finding List," "Canadian Classified Section," and geographical "Trade Facilities Section." This latter lists the following information for each town of over one thousand population: Name of leading commercial body with name of secretary; name of leading bank with name of cashier; names of all railroads; and names of storage and distributing warehouses.

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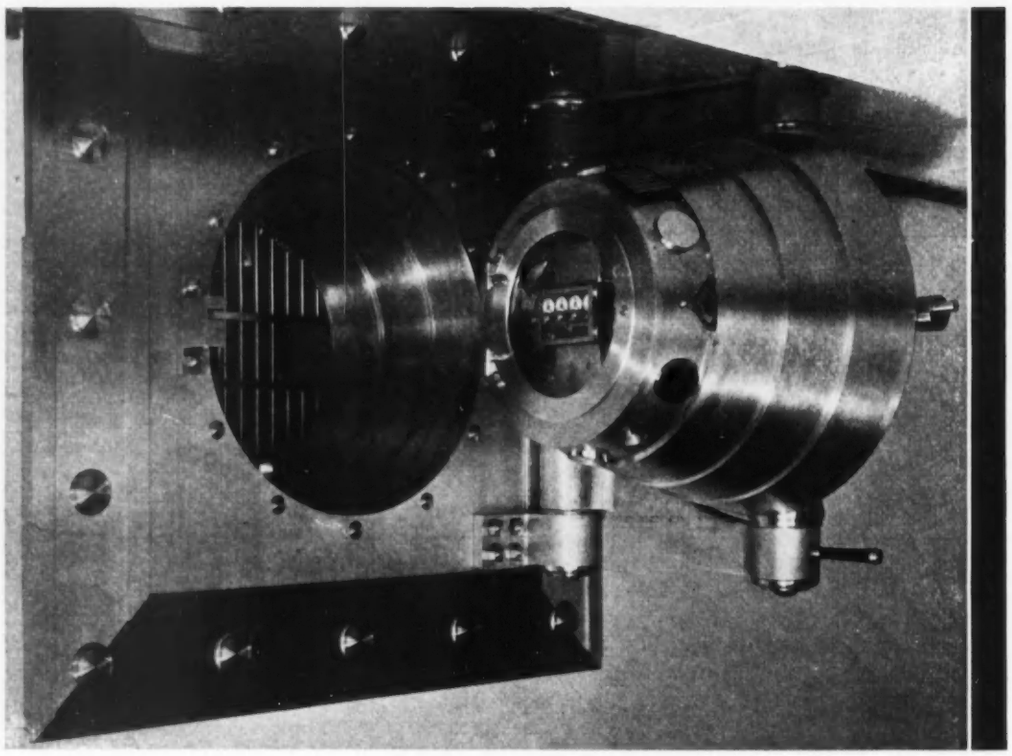
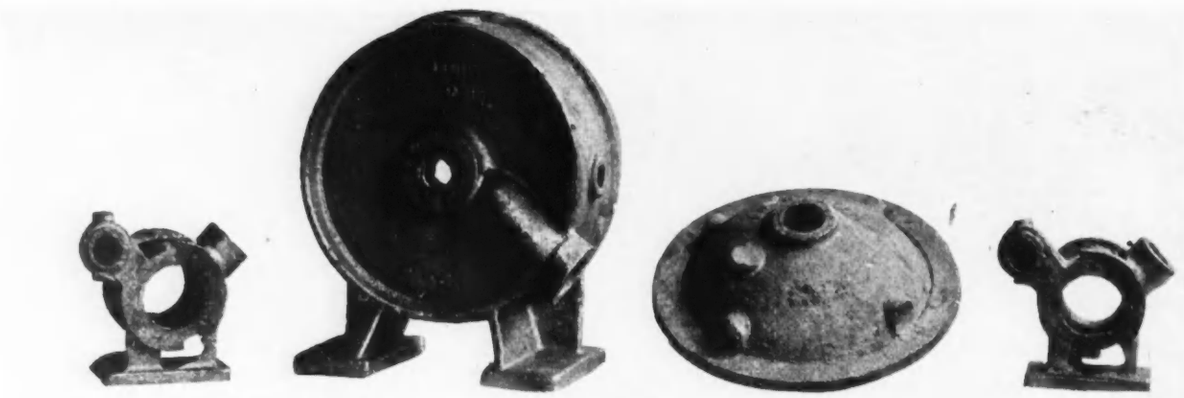
MECHANICAL ENGINEERS' HANDBOOK. THIRD EDITION. *Lionel S. Marks, editor-in-chief, professor of mechanical engineering, Harvard University. 2,264 pages, 4½x7 in. Semi-flexible covers. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Price $7.*

THE size of this handbook has been materially increased, a new section on vibrations having been added. More space is devoted to theoretical discussions, and the physical data have been revised to represent currently accepted values. The discussion on welding has been expanded, and a number of new special subjects are dealt with, such as, industrial combustion furnaces, electric furnaces, and high- and low-pressure carbonization of coal. The increasing degree of specialization in mechanical engineering is reflected in the increase in contributors, who now number more than seventy-five.



Photographs from the American Stainless Steel Company and Lebanon Steel Foundry



TWO COMPLETE PRODUCTS OF STAINLESS STEEL

All parts of a food-mixing machine are stainless steel castings; the emergency vault door above shows the machineability of this alloy.

A COMPLETELY ELECTRIFIED TYPEWRITER

A FINISHED JOB of product engineering, the Electromatic typewriter. built largely from die castings, stampings, screw machine parts, molded parts and electrical units

Designed for high-speed typing with minimum fatigue of operator

▼

By Russell G. Thompson
Vice-President and General Manager

and Chester W. Crumrine
Development Engineer,
Electromatic Typewriters, Inc.

IN DESIGNING the Electromatic typewriter it was our purpose to build a simplified writing machine, in which every movement would be performed by electric power. The design of the typewriter, "from the ground up," was for power actuation of all parts; it was in no sense a mere application of power to parts of a machine built originally for manual operation. We were not handicapped by the necessity of using parts of machines designed for another kind of operation. Naturally, the result is a different kind of writing machine with many novel features.

Our three main objectives were: to increase typing speed, to minimize fatigue of the operator, and to produce uniform writing, regardless of the operator's touch. Other important considerations were to make parts simple in design for easy manufacture, and strong and enduring to assure long service.

Simplicity in design, together with the use of aluminum die castings for the frame, base, motor, and other parts, results in an electric typewriter of approximately the same total number of parts and the same weight as manually operated typewriters now in general use. To assure moderate cost, nearly all the remaining parts were either steel stampings, screw machine products or molded Bakelite.

We broke away from the accepted practice in many instances, in order to obtain as simple construction as possible, with the fewest possible number of parts. The escapement mechanism, for example, has only four principal parts, as compared with 60 or more in other machines. In other cases one lever or group of levers has been designed to perform several functions, thereby doing away with interlocks, which otherwise would be necessary to prevent jamming of parts if two keys were pressed at the same time.

Ease of assembly and general accessibility in service work are greatly facilitated by mounting all the key mechanism and its actuating parts on a die-cast sub-frame hinged to the main frame on two dowel pins and fastened to the main frame with four screws. This arrangement makes it unnecessary to perform the assembly operations on most of the small parts in cramped positions while working inside a box-like frame.

Clean-cut external appearance, substantially complete enclosure, and ease of finishing in any desired color without affecting other production operations, are made possible by using the die-cast main frame and cover shown in accompanying illustrations. These parts are sprayed with black crystallizing enamel or colored lacquer, independent of the remainder of the machine. Aside from drilling and tapping, machining of the main frame is confined to a few simple milling operations. Guide slots in the sub-frame are cast accurately and require no machining.

Increased speed in writing and less fatigue for the typist are the basic reasons in favor of an electrically actuated typewriter. Consequently, another of our objects was to create a design that would permit, not alone the highest speed an expert typist can attain, but a much higher speed, obtainable only when a supplementary mechanism for automatic operation is added to the standard machine.

That minimum fatigue in operation has been obtained is evident, for the pressure required on the keys is only

2 oz., and the distance they are moved only $\frac{1}{8}$ in., as compared with a 2-lb. pressure through $\frac{5}{8}$ in. in average hand machines. In addition, the carriage return, which requires much energy in most hand machines, is accomplished electrically when a key, exactly similar to the character keys and requiring no more pressure to operate, is touched. The net result is that the 120,000 in.-lb. of energy, which a typist who uses a machine all day ordinarily puts into the hand-operated typewriter, is reduced to less than 2 per cent of this figure. Tests on a commercial production basis have shown from 30 to 50 per cent increase in output over hand machines, with decidedly less fatigue to the operators.

Aside from its front cover, the Electromatic typewriter consists of three major assemblies; the main frame, the sub-frame, and the carriage. Four die-castings, held together by screws and positioned by dowels, form the four sides of the main frame. In this assembly are included the motor, switch, rheostat, and all other electrical parts, the rubber-covered power roller, which transmits motor power to the mechanism, the worm gearing, which serves as the speed reduction between the motor and the power roller and its die-cast housing; the carriage ways, escapement, and back-spacing mechanism; and a few other minor parts.

A motor of our own design and construction is employed. It is a universal type normally turning at about 4,500 r.p.m. and capable of operating on any 105 to 125 volt circuit, a.c. or d.c. up to 75 cycles. A motor for 220 volt circuits also is available. All motors have the inherent characteristic of constant speed, regardless of the load employed in their normal operation, and draw from 75 to 100 watts. By setting a small rheostat slide, the voltage applied to the motor and its corresponding speed can be varied. The higher the speed the harder the type blow and the greater the number of carbon copies that can be made.

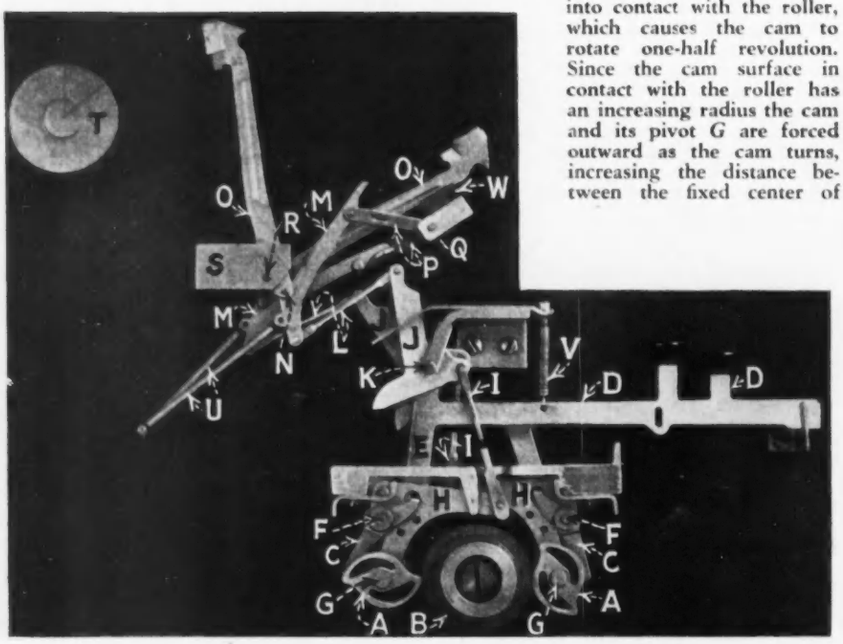
Fitting into the main frame is the sub-frame, which supports all the keys and operating cams; the "basket," containing all the letter and figure characters; the ribbon mechanism and various other parts. This sub-assembly is held into the main frame by two hinge dowel pins and four screws. When the latter are removed, two links disconnected, the assembly can be removed from the machine, thereby affording ready access to all parts.

A feature of this assembly is the mounting of the basket, which is raised and lowered for each capital letter. In each extreme position it is locked securely and automatically by a toggle linkage, assuring perfect alignment. The basket is attached to the sub-frame by four flat springs held to the respective members by screws through each end. These springs give a parallel motion somewhat on the order of a pantograph, but without any sliding or pivoted joints to wear and give play. Moreover, the springs assure positive alignment from side to side in their own planes.

Although the carriage departs less from conventional design than the other assemblies mentioned, it is not without original features. The platen is removable quickly, and provision for fractional spacing is provided. Line spacing is performed automatically as the carriage is returned.

As already noted, the power for performing the various functions of writing, carriage return, back-spacing, line spacing, shifting for capitals, and tabulating is applied by the rubber-

Model Showing Typewriter Action



THIS MODEL made from actual machine parts in correct relative position, illustrates a fore-and-aft section through the machine. It shows two key bars and two type bars with the intervening and power-drive mechanism.

Normally, each cam *A* is held out of engagement with the roller *B* by a release lever *C* which catches under a lug on the side of the cam. When a key lever *D* is pressed, a slot in its downwardly projecting leg *E*, engaging one end of the small release lever *C*, moves the lever about its axis *F*, thereby disengaging the lower end of the lever *C* from the cam lug or stop. This permits a spring to draw the cam *A* into contact with the roller, which causes the cam to rotate one-half revolution. Since the cam surface in contact with the roller has an increasing radius the cam and its pivot *G* are forced outward as the cam turns, increasing the distance between the fixed center of roller *B* and pivot *G*, which is on the lower end of the bell crank *H*. The other end of this bell crank consequently moves downward, pulling on the link *I*, and turning the bell crank *J* about the fixed pivot *K*. Tension link *L* is attached to the lower end of a third bell crank *M*, which is pivoted at *N* on the lower end of the type bar *O* and forms, with the link *P*, one half of a toggle. At its forward end, the link *P* turns about the fixed pivot *Q*.

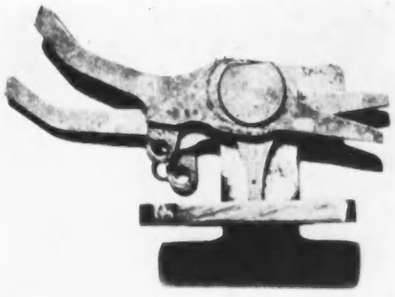
All type bars are hinged on the fixed pivot *R* and are hardened and ground on both sides and guided by close fits in the sawed slots of the cast-iron type bar segment *S*. It requires only a very light pull on the link *L* to "break" the toggle and thereafter, in continuing the same motion, to pull the bell crank *M* forward bodily, thereby causing the type bar *O* to turn about its fixed pivot *R* until its upper end, carrying the type, strikes the ribbon against the paper and platen *T*, printing the corresponding character.

By the time the cam *A* has made one-half revolution, the lever *C*, now actuated by the return spring *V*, attached to the key bar *D*, engages a second stop on the cam face and again holds the cam just clear of the power roller, ready for repeating the motion when the key bar *D* is pressed again. At the same instant the spring returns the type bars and interconnected linkage to their normal "off" position, drawing the toggle just past center. This latter feature is of great importance, because, when the returning type bar *O* strikes against the felt pad *W* it tends to rebound, an action which the toggle prevents. Except for this, a rebounding bar would be likely to strike or jam with the bar next actuated and thereby reduce the possible speed of writing.

THREE major assemblies and cover of the Electromatic typewriter: the carriage, subframe assembly, containing most of the mechanism, and the base with motor, gearing and power roller installed

faced motor driven roller, shown in accompanying sections. Aside from putting paper into the machine in the usual way, all the typist needs to do is to press the necessary keys or space bar. This results in bringing the corresponding cams into contact with the roller surface. The cams then instantly turn through one-half revolution, and in so doing, actuate type bars, which write characters or perform some other function corresponding to the key pressed.

Nearly all the cams are identical and have a pair of serrated elliptical-arc surfaces disposed eccentrically to



AN ESCAPEMENT with about one-fifteenth the number of parts ordinarily used

the axis, as shown in the illustrations. The cams are arranged in two rows. The rearward row is operated by the keys in the two upper banks, and those in the forward row by keys in the two lower banks. Each cam is pivoted on one end of a bell crank forming part of the linkage it operates. Normally, a stop on the side of the cam holds each cam a few thousandths of an inch out of contact with the roller surface, but when the key corresponding to a given cam is pressed, a spring forces the serrated surface of the cam against the soft rubber surface of the roller and the two rotate together without slippage. In so doing, the cam pivot and the link to which it is attached are forced outward, away from the roller, because of the increasing radius of the cam. It is this motion, for which the motor supplies the power, that actuates the type bar.

Details of this arrangement are important, for upon them are based the entire functioning of the machine. The linkage and other elements involved are shown in the accompanying lettered illustration, and a description of their operation is given in the caption.

In a machine designed not alone for maximum speed in manual writing, but also for automatic writing at a much higher speed, the utility of the anti-rebound toggle, shown in the lettered cut, is apparent. It is also a good example of the care used to prevent jamming.

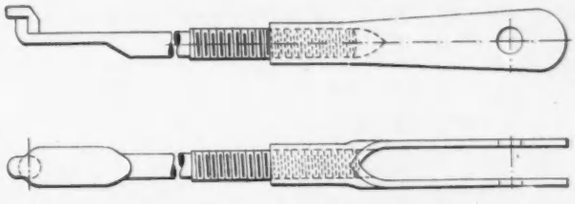
Key levers, bell cranks, type bars and some other parts of the mechanism are made from fairly high carbon (0.40 to 0.50 per cent) steel, spot-hardened at bearing points. Other levers, links, pivot rivets, wires and screws are given a five-minute cyanide case and then are quenched in oil. The design is such as to require a minimum of bending during assembly operations.

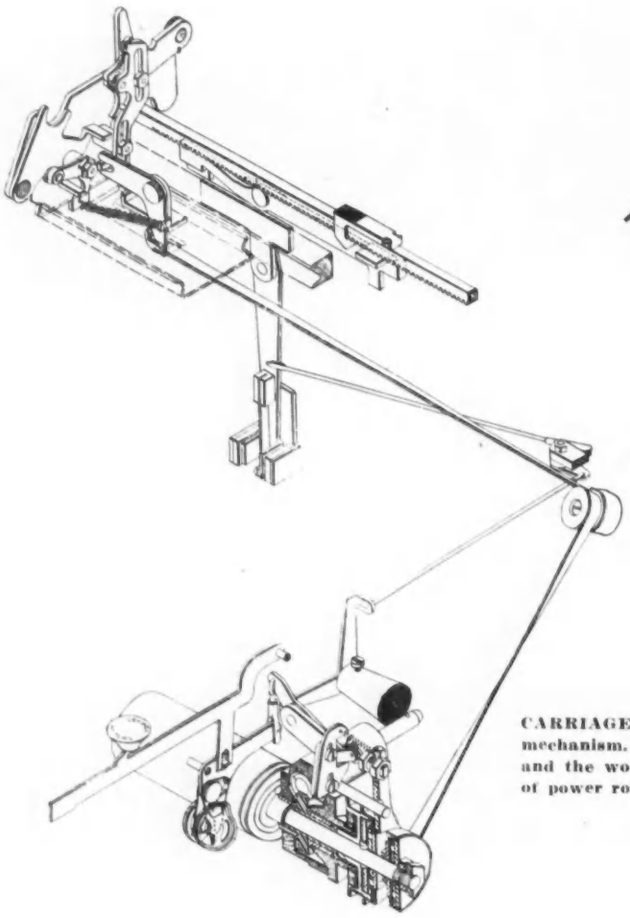
Parts are provided with side guides, such as the stamped comb at the front of key levers, wherever such a guide is needed. Assembly is facilitated by employing links with a cranked offset at one end, so arranged that it can be slipped through a hole in a stamped part and then is locked against axial motion in the hole by simply swinging the link into the plane of the mating part. Clevices used on the other end of such links are stamped and formed from sheet metal, the shank threaded, and the part cyanided. Most sheet metal parts are tumbled in sand and water to remove burrs and to give a clean smooth surface. Key levers and other exposed metal parts are chromium plated and polished to improve appearance. Key pads are of mottled Bakelite with a brass ring insert into which the lever end snaps when the pad is pressed onto it.

Two independent V-groove rails, carefully ground, form the carriage ways. The carriage base is a specially rolled channel section with ground V-grooves in each leg. Four $\frac{5}{16}$-in. ground balls roll in the V-grooves and support the carriage. Mounted upon the rear rail and operating directly on the carriage rack, is the simple escapement consisting of two pawls pivoted on the same stud, riveted to a suitable bracket, and operating alternately.

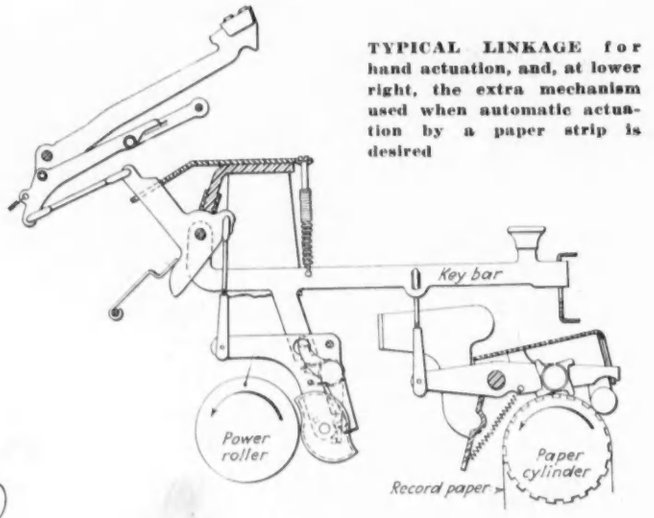
One of the features of the machine is the power-operated carriage return and line spacer. As indicated in the isometric drawing, the single-lobe cam contacting with the power roller is thrown into engagement by pressing the carriage return key. The cam, acting through the bell crank upon which it is mounted, straightens out a toggle mechanism, thereby shifting a lever which engages a small friction clutch keyed to the right end of the power roller shaft. The driven member of the clutch engages a pulley about which the carriage return tape, passing over a ball bearing idler

CONNECTING LINK with cranked end, and sheet steel clevis used for joining many parts of the mechanism





CARRIAGE - RETURN mechanism. The clutch and the worm gear drive of power roller are shown



TYPICAL LINKAGE for hand actuation, and, at lower right, the extra mechanism used when automatic actuation by a paper strip is desired

pulley, is wound as the carriage is drawn to the right.

The carriage return tape is attached to the line spacing mechanism and consequently the same pull on this tape which returns the carriage also indexes the platen one or more spaces.

In the isometric drawing is also shown the mounting of the ground steel worm and linen-base Formica worm gear which form the reduction between the motor and the power roller. The bearings for this pair of gears, as well as those of the motor and power roller, are of Moraine porous graphite bronze, which soaks up a large quantity of lubricant. The gears are packed in lubricant, and space for a supply sufficient for all the bearings mentioned is left adjacent to them. At nearly all movable joints in the machine turning motion has been employed in preference to sliding motion, and points where wear is likely to occur are hardened. As a result of this and of proper lubrication at critical points, friction has been mimimized and the life of the machine increased, we estimate, to about five times that of ordinary typewriters.

A factor making for increased speed is that the hands of the operator never need be removed from the keyboard while writing, and, since the key motion required is only $\frac{1}{8}$ in., the steps in the key banks are only $\frac{5}{32}$ in. high, about one-fourth that in average machines.

All parts of the machine are exceptionally accessible both for assembly and service operations, yet parts needing protection from dirt are well inclosed.

Finally, the writing is clearly visible at all times, the machine is attractive in appearance, but without unnecessary embellishment, and its operation is substantially fool-proof. Since all type bars are mechanically operated with the same force, the writing is much more uniform than when manual "touch" is involved.

Beyond all this the standard Electromatic typewriter is so designed that a simple supplementary device can be built in, which will enable it to write letters automatically. The typist, in this case, need only fill in the address, an operation which can be done while the letter is still in the machine. The automatic device does not interfere with normal use of a machine for writing individual letters.

In applying the automatic control to the standard machine a second cylinder is added $4\frac{1}{2}$ in. forward of the rubber-covered power roller. This cylinder has a series of 20 longitudinal grooves or splines cut in its metal surface and is positively driven by a worm wheel meshing with a worm on an extension of the same shaft that drives the power-roller worm. The forward cylinder is easily removable for insertion of the loop of record paper which passes over its surface and is driven positively by pins that enter the perforations in each side of the paper.

Springs hold against the paper surface a series of small star wheels pivoted on short levers, of which there is one for each key bar. These levers have a fixed pivot and their rearward ends are connected by pivoted links to the respective key bar which they actuate. The upper ends of the links ride in slots punched in the key bars and do not affect manual actuation of the keys. Normally, the star wheels ride on the surface of the paper, but when a perforation passes under one of the rounded star points, this point drops through the hole and into the groove on the cylinder under it, where it catches against the edge of the groove. Since the cylinder is turning, it rotates the star wheel and in so doing raises the lever on which the wheel is mounted, actuating the corresponding key bar and performing the same function as if the key were manually actuated.

As the cylinder continues to rotate the star wheel point lifts out of the slot, which has taken all the load, and out of the perforation. With this construction there is no wear on the paper roll or on its perforations, hence the roll can be used indefinitely, reproducing the same letter as many times as desired

A NEW FIELD OF FINISHES

Co-deposition of two or more metals is now commercially possible

An interview with
COLIN G. FINK
Head, Division of Electrochemistry, Columbia University

TO THE designer who has the problem of specifying the proper finish for his particular product to meet the conditions that the user will impose on that product, two factors invariably occur: choice of color, and corrosion resistance. The first is an almost intangible item, and its answer lies in the determination of that color which will be pleasing to the largest number of users of the particular product. Naturally, also, it must be fitting to the conditions surrounding the use of the product. The item of corrosion resistance may be stated as the relative ability of the finish to maintain its original color and surface under the particular conditions of exposure to which it will be subjected in service.

Plating, fundamentally, is an attempt to obtain the color and the resistivity of a relatively expensive metal by the deposition of a thin coating over a cheaper base metal. Since prehistoric times, the two metals, gold and silver, have been standards of value in the color judgment of metals. Gold has been imitated in color from ancient times by bronzes, but no metal combinations were ever found by the alchemists to imitate the white color of silver. Silver is too soft and too expensive for general use as a plating metal for commercial product parts. Therefore, until the advent of chromium plating in 1924, nickel was practically alone in this field.

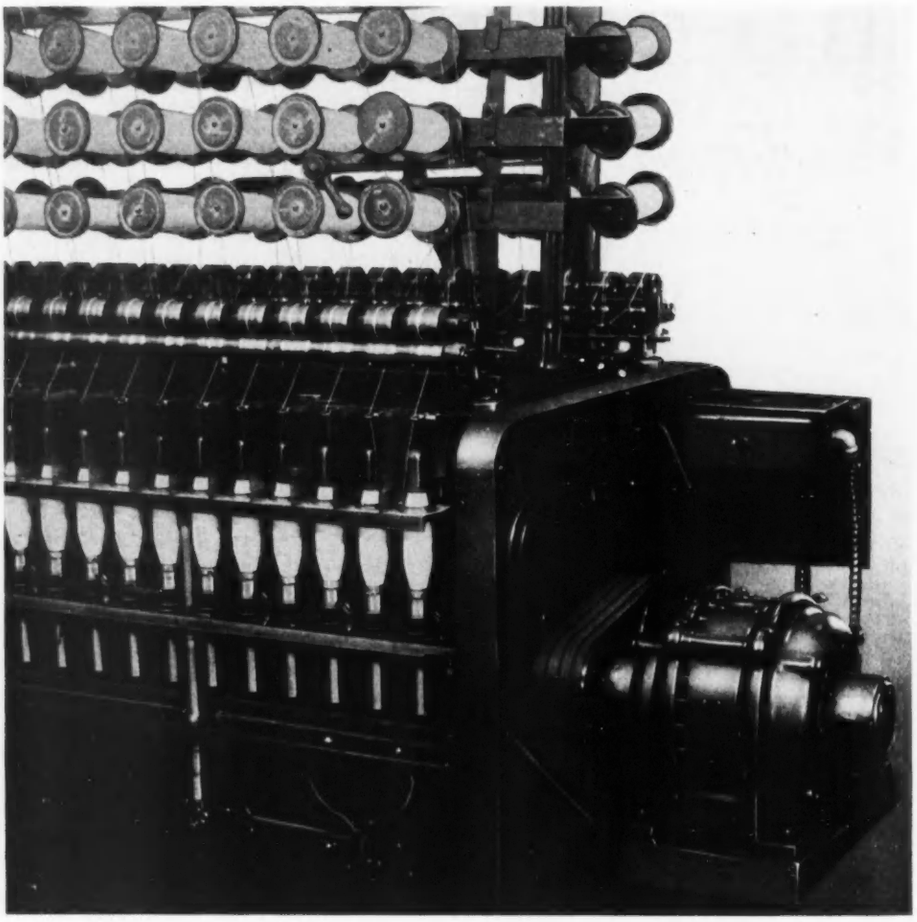
Chromium is eminently satisfactory as a plating material for a great variety of products. Chromium plate has entirely replaced that of nickel for finishing automobile parts, even though it is conventionally applied in a very thin coat over previous plates of copper and nickel. In the case of household electrical appliances where large surface areas are involved, one manufacturer reports 70 per cent of his products are produced in chromium. But it is in this type of product that personal preference of the user enters strongly. Householders for generations have been accustomed to the white color of silver, and are consequently prone to judge all plate on that basis. Nickel has a decidedly yellowish cast and does not match with silverware. Chromium has a blue cast, but has gained favor over nickel because of the ease of obtaining a high, bright polish. It now remained for modern alchemy to provide a metal finish approximating the color of silver but with some of the wear and corrosion resistance of chromium.

It has been known for some time that by alloying nickel and cobalt in definite proportions, a product is obtained which is almost pure white in color, the blue of the cobalt neutralizing the yellow of the nickel, just as a housewife neutralizes the yellow of linen (due usually to iron in the wash water) with "blueing." Research was, therefore, undertaken to determine methods of electro-depositing these two metals simultaneously to produce a silver-white alloy plate. The results have been satisfactory.

Nickel-cobalt plates are entirely practical with nickel and cobalt anodes, using combined nickel sulphate and cobalt sulphate solutions in the plating baths. Plates obtained are white and almost identical in color with silver, within the wide range of 55 to 75 per cent nickel and 45 to 25 per cent cobalt. They have the advantages, however, of being harder and more wear-resistant, and also more corrosion-resistant than either nickel or cobalt alone. For example, plates of this character are three times as hard as a plate of nickel alone. In fact, measurements by the scratch hardness method of various metals to show their resistance to abrasion showed a scratch hardness equal to that of a pure cobalt plate for a plate containing but 25 per cent of cobalt. Microcut widths of 20 microns for the 75Ni-25Co and 66.5Ni-33.5Co plates compare very favorably with widths of 34 for rolled nickel, 36 for hard brass, 48 for hard rolled copper, 56 for hard Duralumin, 76 for roller tin, and 144 for rolled lead, by the same method. Even an 85Ni-15Co plate showed a microcut width of only 26 microns. Moreover, nickel-cobalt plates do not take on a yellow tint as silver does when exposed but a very short time to city atmospheres in which sulphur is present, and newly discovered cobalt in copper-ore deposits of the Belgian Congo is expected to lower its price from the present value of five or six times the price of nickel.

Another research investigation has demonstrated recently the possibilities of depositing alloy plates of lead-thallium. Alloys of this kind, containing anywhere from 20 to 65 per cent T1, are among the most insoluble known, and should find use for coating parts of chemical machinery. They form very acid-resistant surfaces on iron, steel, and non-ferrous metals, are harder than either lead or thallium alone, and form good, smooth, adherent, plated deposits. Most economical of these alloys in the most insoluble range is that containing 70 per cent lead.

The co-deposition of metals, or in other words, the plating of alloyed metals on product parts, offers wide possibilities, especially in utilizing the rare and noble metals to obtain their peculiar properties of color and acid resistance where the cost of the solid metal would otherwise be prohibitive, or where strength requirements make it necessary to design the part of steel or other strong metal when a particular color of finish is desired.



TEXTILE SPINNING frames must start and stop without breaking threads, and have a continuous even pull on the threads

Uniform Power Transmission With V-Belts

By R. E. S. GEARE
Engineer, L. H. Gilmer Company

MORE exact requirements in modern machines, and more exact thinking on the problems of reduction of losses in the transmission of power have brought home to the designer the necessity of considering more closely the fundamentals of efficient transmission in machine drives. This problem has been accentuated by the rapid growth of direct motor drive, where in order to obtain flexibility and smoothness some type of belt or flexible connecting drive is required, and short center distances are frequently the rule. The machine designer should not consider his drive a thing apart for the customer to specify, but rather a problem that he himself must consider in relation to the proper operation of the machine and the results which he desires to obtain.

In the March number of *Product Engineering*, the general subject of the V-belt as a driving medium was discussed. This article will discuss sagging and whipping and their relation to the V-belt as a power transmitting medium to replace the flat type belt.

It is assumed in any multiple-V drive that all of the belts are taking their proportion of the load, and are doing the pulling at the pitch line of the V-groove sheave. In actual practice, however, several things may occur to one or more belts to cause an unequal distribution of load: (1) Sag of one of the belts caused by stretch or a longer belt; (2) whipping sideways on the slack side caused by the belt not having sufficient body or reinforcement against lateral movement; (3) whipping up and down caused by insufficient body, or by inaccurate or dirty grooves in the sheaves. Reinforcement of the belt itself, of course, must be taken care of in the build-

ing of the belt, and there must be assured a uniformity in the belt structure and the position of the neutral axis of the several belts in any particular drive.

It is desirable from a standpoint of efficiency to have all belts of an exact length. With the slack side on top, an increase of length in belt results in an increase in sag, and there will be a greater arc of contact on each sheave, and hence more power transmitted by that belt than the others in the drive. This unequal loading is undesirable. Usually there is no advantage to be gained by increasing the arc of contact by running the belt slack, as in the case of flat belts. The tremendous frictional grip of the V-belts in their grooves practically precludes the possibility of slipping. Incidentally, V-belts are usually rated for 180-deg. arc of contact and have an efficiency of transmission as high as 98 per cent.

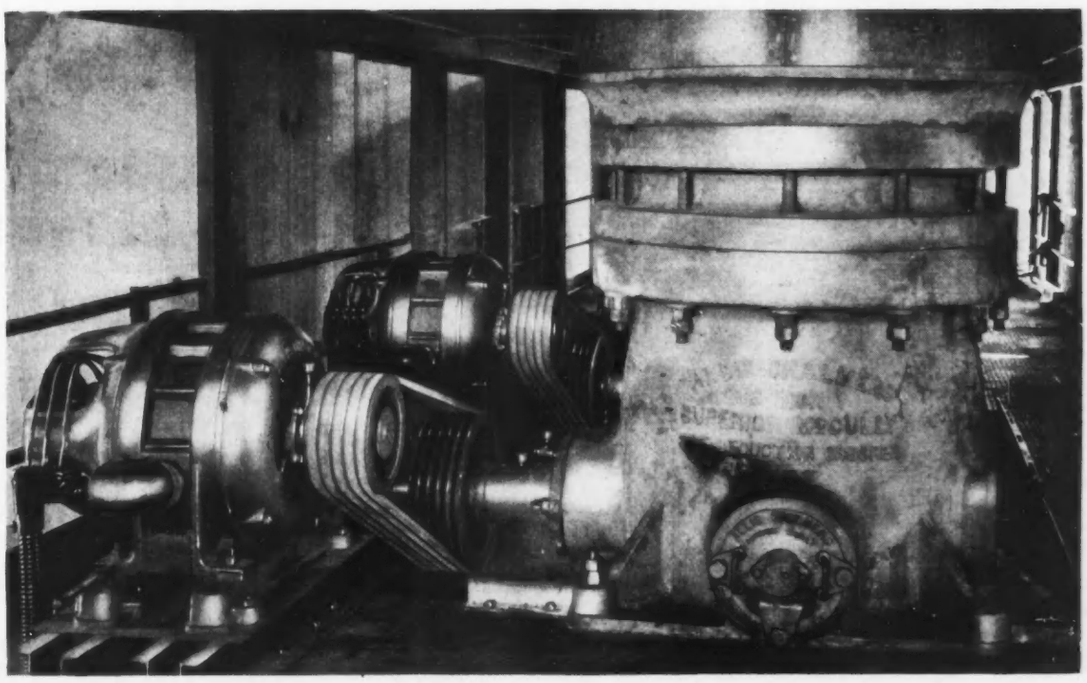
When an observer sees one belt showing a greater sag than others, the usual conclusion is that there is a large stretch in that particular belt. The sag may be great, yet a very small increase in belt length will create a large sag. Considering a belt with 10-in. center distances between sheaves, an increase of $\frac{1}{2}$ in. in the length of the belt will cause a sag of 1.6 in., while the same $\frac{1}{2}$ in. increase in length of belt will cause a sag of 3.5 in. where the center distance between sheaves is 50 in. It is apparent, therefore, that the difference in sag increases for a given difference in length of belts in proportion to the distance between centers. Thus, only a very slight stretching of a belt on a fairly long center distance is sufficient to cause that belt to sag and pull unevenly.

WHEN a belt is going around a sheave the inner section is under compression and the outer under tension. There is, therefore, a pitch line or neutral plane where there is neither tension nor compression. It is very important that the power cord or fabric which has relatively low elasticity be located as close to the neutral axis as possible, as it will then be subjected to a minimum of stress resulting from elongation and compression. The distribution of this fabric should not be equally above and below the neutral axis, as determined when the belt is straight. Following the laws of stress distribution in curved beams subjected to bending, the neutral plane or axis of the belt shifts toward the center of curvature when the belt is bent in going around the sheave. Therefore, the fabric should be distributed as closely as possible to the plane representing the average position of the neutral axis. If the power cord or fabric lies uniformly along this neutral axis, and has been uniformly treated and imbedded in all of the belts of the unit, the possibility that one of the belts will stretch more than another is reduced to a minimum.

AN impervious covering of uniform quality should be provided on a V-belt to prevent the entrance of oil or moisture. This also eliminates having two or more different coefficients of friction, as are present in a belt having more than one kind of material in contact with the sheave face. The latter condition may cause squeak, whipping, or splitting apart of the belt, resulting from the differences in intensity with which the different materials grip in the grooves of the sheaves.

When the starting load is thrown on a V-belt drive, the belts must first be forced down into the grooves before the full forces can be transmitted. The load is picked up gradually as the belt seats itself into the groove, giving a shock-absorbing effect not present in flat belts, and entirely independent of the elasticity of the belt itself. This is an ideal condition, and is most valuable on textile machines where any shock in starting or stopping may break the delicate threads.

Inaccurate and dirty grooves can cause whipping, and reflect discredit on an otherwise good design of drive. If all grooves are cut absolutely correct and are finished equally smooth, the shock-absorbing action described above will take place simultaneously in each belt of the drive, and the most favorable conditions will prevail for a smooth drive. On the other hand, assuming that one of the angles of a groove is incorrect in relation to the

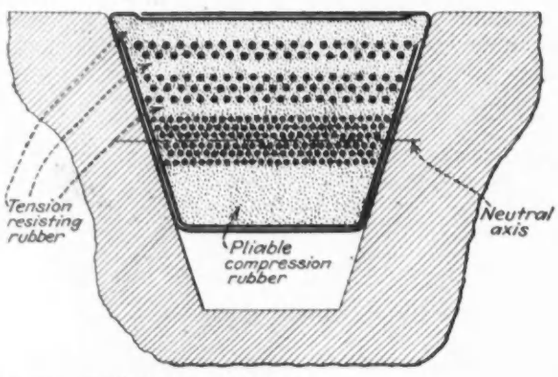


GYRATORY ROCK CRUSHER in which sudden changes of load with different sizes of rock are smoothed out by V-belt connection

other, or that foreign matter has been deposited on one side of a correctly cut groove, or that the sides of one groove are roughly machined, the belt in the defective groove will ride high and thereby tend to increase the tension in that particular belt. The other belts will have the appearance of sagging. A similar, or reverse, condition can also be caused by a difference in the angles of a sheave.

Much has been written about the advantages of the V-belt on short center work, which is important where the machine drive is from an attached motor or speed reducer. Of just as much importance is the advantage of shock elimination in starting and stopping. Another important advantage is the minimizing of the pressure on the bearings of the sheave shafts. This is because of the fact that a V-belt will transmit power at maximum efficiency without the necessity of excessive tightening. One very distinct advantage of V-belts is their application to high speed machines. Ordinary flat belts, running at high speed, are thrown away from the pulley face by centrifugal force. Also, a cushion of air is sucked in under the belt. The result is, the belt rides off the pulley. But in V-belt drives there is a very strong grip holding the belt in its groove. Also, the air space between the bottom of the belt and the groove prevents the building up of a cushion of air. Thus, it is entirely feasible to use a V-belt on high-speed drives, even when the use of a flat belt is impossible.

The V-belt has grown tremendously in its applications within a relatively short space of time. Unlike the ordinary flat belt, operators should not be, and do not expect to be, obliged to alter or make replacements frequently on V-belts. A troublesome V-belt drive is a reflection on the designer. Added attention is, therefore, necessary on the part of the machine designer to see that he has the right V-belt drive for the purpose, and that the elements are correctly designed.



EVEN SEATING of a V-belt is important, and pull must be uniform along the neutral axis

It has been common practice among builders of plant equipment to put it up to the customer to select the type of main drive. This is still being done by some manufacturers, but is an unsatisfactory procedure. Most machines require very definite characteristics in their drive. Thus, a rock crusher will operate most efficiently with a proper belt drive, as that type of drive minimizes the severe shocks to which the machine may be subjected. Fewer breakdowns, longer life, and a better reputation for the machine, are the results. This illustrates why the engineer should specify and design the drives.

▼ ▼

Why Black Tops?

By Paul B. Swinton

COLOR is an extremely important factor in the finishing of products. The automobile manufacturers were probably the pioneers in increasing the sales appeal of their product by a tasty selection of colors. Manufacturers of other products followed suit when the commercial development of lacquers made color schemes and the diversification of colors an economic possibility. Colors blossomed forth in practically all lines of product, from the humble kitchen clock to the magnificent locomotive. The profession of "art director" came into its own. But harken to this monologue by one of the leaders in that field.

"It is not only the artistic appearance that must be considered," continued my Art Director friend, after he sank his putt. "The color must above all be pleasing. But the selection is limited by other considerations. Corrosion resistance or inertness in the presence of certain chemical fumes, is a very common requirement in a finish. Exposure to sunlight is always an important consideration. The effect of surface finish on heat dissipation is another factor—but it is too often overlooked.

"Electric irons are nickel plated. The bright finish reflects the heat back into the iron, materially decreasing the intensity of the heat radiated against the hand holding the iron. In railroad tank cars we have the reverse condition. A few years ago the shippers of gasoline woke up to the fact that a coat of bright aluminum paint cuts down the heat absorbed by the tank. Evaporation losses are thereby materially reduced. For that reason those pretty tank cars you see are painted with aluminum.

"But many people do not seem to appreciate the heat-throwing factor in the selection of the finish. Home radiators are still being painted a bright color. A dead black is several times more efficient in the amount of heat thrown off. One manufacturer of automobiles created a sensation by coming out with a completely nickel-plated radiator. People wondered why the engine became overheated.

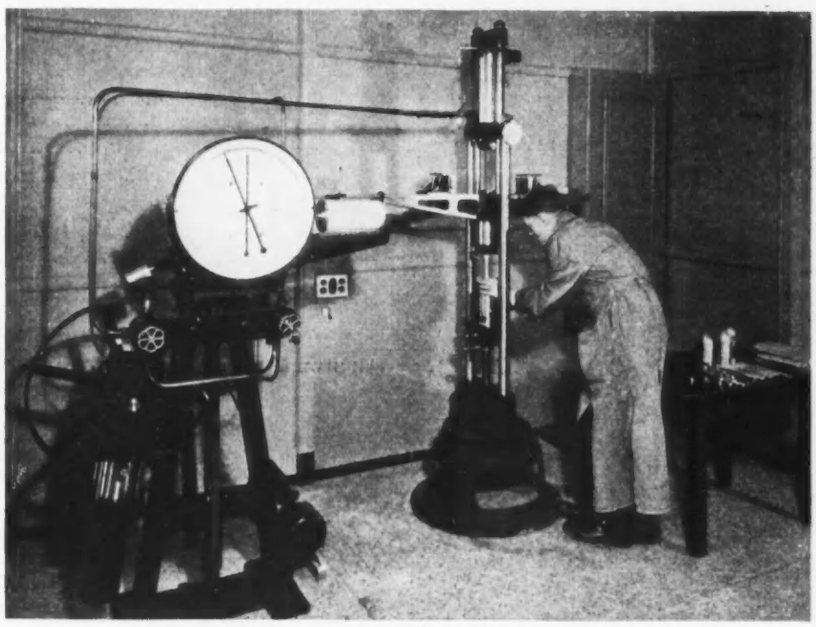
"The double-walled glass flask, as used in thermos bottles, is a striking example of the effect of the reflecting power of a finish on the heat losses. Hot liquid put in such a vacuum bottle, will lose 5 or 10 deg. of temperature in one hour, if the flask is of plain glass. But these flasks are usually silvered, with the result that the temperature of their hot or cold contents changes only a fraction of a degree per hour.

"A dead black surface radiates heat about 30 times faster than a brightly polished silver surface, about 15 times faster than polished brass, and about 1½ times as fast as an ordinaary unfinished iron surface. Of course, these figures are approximations, as surface smoothness also has an appreciable effect on heat radiation. Rougher surfaces throw off more heat.

"These facts are really common knowledge. But it is surprising how frequently we find the color and finish factor ignored in problems involving heat transmission. Parts designed to radiate heat are too often given a beautiful silvery finish merely because it looks nice."

I drove back to town from the country club in my closed car. It had stood out in the sun all afternoon, and was terribly hot inside. I wondered how much cooler it would have been, had the top of the car been painted a bright color instead of the conventional black.

A LABORATORY LINE-UP for Vacuum Cleaners



AMSLER hydraulic testing machine, one of the several types of machine used in the Hoover laboratories

The second of two articles on Hoover engineering and product development

An Interview with
D. G. Smellie
Director of Development and Design, The Hoover Company

IN A PREVIOUS article it was shown how the engineering department of the Hoover Company is organized and operated. In the present article this company's very complete laboratory, drafting room, and experimental shop facilities are described. The Hoover policy, in general, is to supply any piece of laboratory apparatus necessary to carry on the major research programs. Much of this equipment is special because of the originality of the work, that is, answers are sought to questions that would arise only in connection with the design and development of a vacuum cleaner.

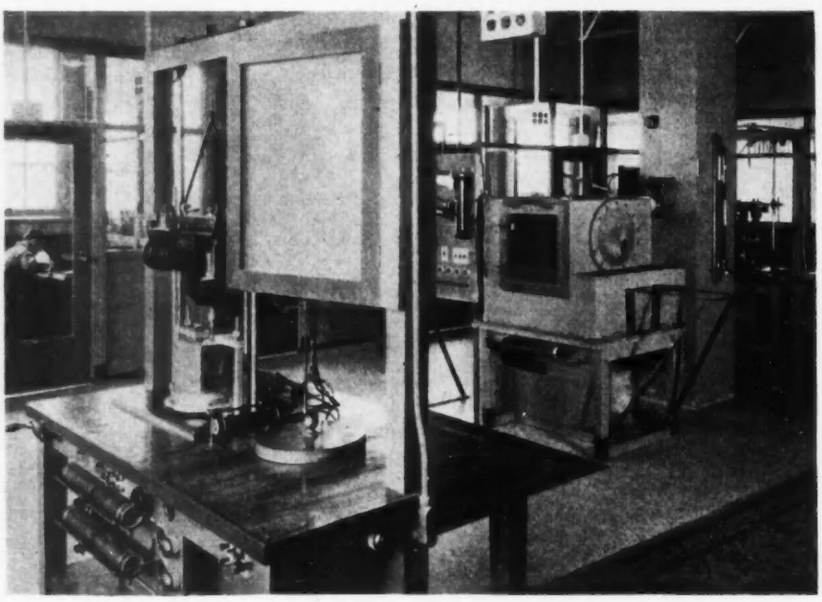
A building of substantial construction and pleasing design houses the various laboratories and provides plenty of room for them and for offices. Glass and metal partitions are used on all floors. Each section is under lock and key.

Facilities in the new engineering building include a chemical and metallurgical research laboratory, an electrical laboratory, a mechanical laboratory, parts testing room, cleaner research room, sample room, lecture and exhibit room, experimental shop, drafting and record rooms, and a library. To insure best lighting, the drafting rooms are located on the top floor. The section known as the drafting room proper is largely for production drawings; the other, the development department, is for initial design. Both have northern window exposure. Glass partitions between tables provide privacy and tend to minimize conversation. Each man has a window with heat and ventilation under his own control—a factor that has been responsible for a noticeable increase in production.

In the development section, mostly senior draftsmen are employed. They are recruited from general industry, and are culled carefully from a large number of applicants having unusual qualifications, originality being a prerequisite. Junior men having the necessary qualifications are promoted from the drafting room or secured from outside sources. A small workshop adjoins the development department and offers an opportunity for practical application of etherial ideas. Samples of standard purchased parts, as well as catalogs classified by product, are available as further aids to the designers.

On the top floor also are the record department, by which all records, sketches, and drawings are issued; the library; the stenographic department; executive offices; and an interviewing room. A double roof and double skylight, together with cork insulation and positive ventilation make this floor comfortable, even in the hottest weather.

The chemical and metallurgical laboratory is located



MUCH of the apparatus in this Hoover mechanical laboratory has been developed in the experimental shop

on the third floor. One of its chief functions is to check raw materials purchased on specification, die-casting alloys, and steel for die-casting dies. It also supervises plating operations.

Fractional-horsepower motors long have been a specialty of the company, and it is largely with the development of this product that the electrical laboratory is concerned. For this work special dynamometers have been developed, accurate to 0.001 hp. and capable of being operated at speeds of 25,000 r.p.m.

Fans, housings, and other parts are tested in the mechanical laboratory. Most of the equipment is entirely special, and was built in the experimental shop. Fundamental research on small fan characteristics has been carried on with this special apparatus. For the investigation of filtering materials the company has provided a textile laboratory in which the humidity can be varied from 20 to 100 per cent. Although the Hoover Company does not manufacture its own cloth, it has controlled and directed the development work along this line in the plants of suppliers.

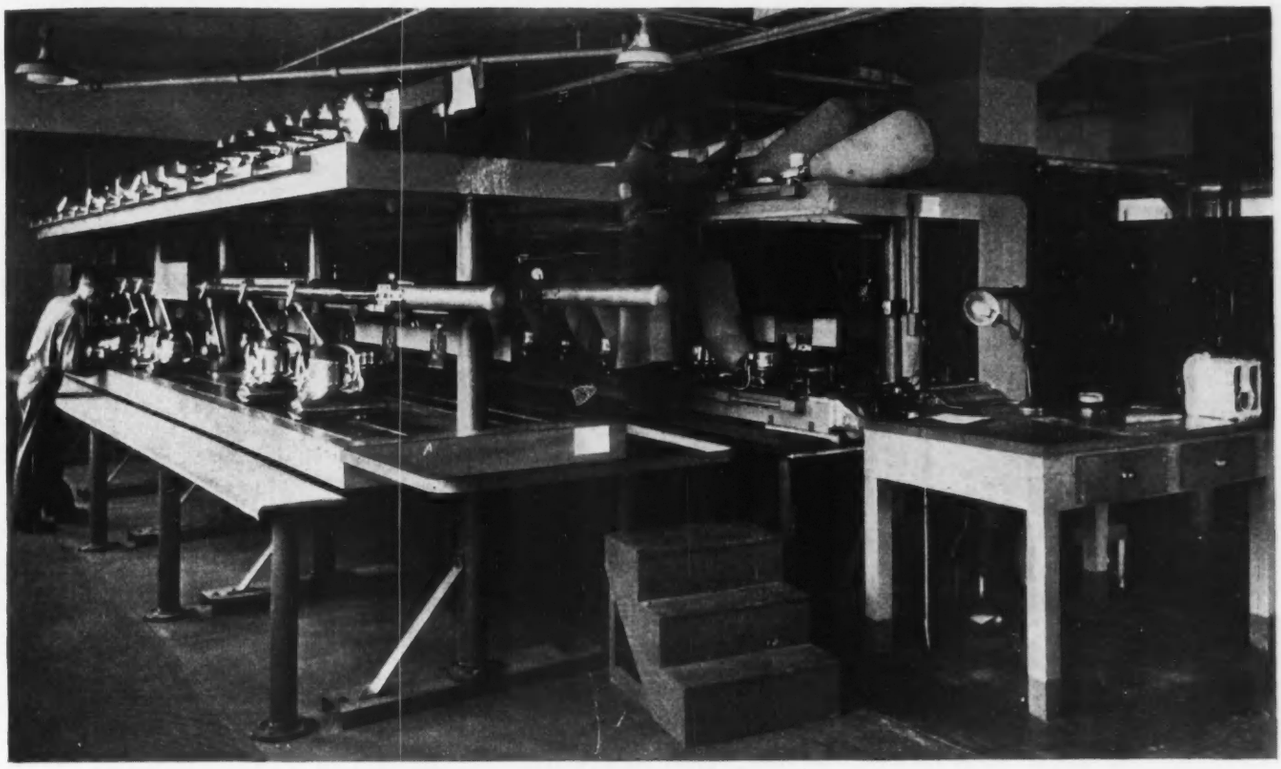
In the parts testing labbratory accelerated life tests are conducted on such items as brushes, wheels, fans and bearings. In some instances, the conditions imposed approximate those encountered in actual service, as in the case of power "operators" used to push cleaners back and forth over a slowly moving rug. In other cases, the cleaners may be pushed rapidly over floor obstructions to see if any part will break or rattle loose in a given time, generally 200 hours. Another example of an accelerated test is that given by a machine, which, in 24 hours, feeds approximately, 1,000 lb. of sand through the cleaner to reveal the effect of erosion. Other ingenious equipment has been devised for testing cord against abrasion, twisting, and wrapping around clips on the cleaner handle. This apparatus is also employed for testing competitive products.

The efficiency of the vacuum cleaner as a unit is measured in the cleaner research laboratory. While it is impossible to duplicate actual field conditions because of the caking effect produced in dirt by the presence of oil and moisture, two standard dirt-removing tests have been devised that are valuable for comparative purposes. In one, sand is embedded in sample rugs by a special impregnator; in the other, humidified dirt, which has been removed from machines returned to the service department, is employed. By weighing the dirt or sand collected by a cleaner under test, the efficiency of the unit can be checked. Samples of a wide variety of rugs are available in this department to study the ease or difficulty in cleaning them. Incidentally, all dirt used in these experiments is sterilized before use.

Complete facilities for building models and laboratory apparatus are found in the experimental shop on the first floor, where twenty craftsmen are employed, each of whom has his own bench and is free to use all the machine-tool equipment, consisting of the usual run of toolroom machinery. Many times, models are prepared from rough sketches, but production developments are made from finished drawings with the production tolerances specified. This shop is under the direct supervision of the engineering department, and is not in any way responsible to the production department.

In order to preserve a record of the past the Hoover Company has brought together in a "models and

DIRT-REMOVING ability of Hoover and competitive cleaners is measured under a standardized condition in this cleaner test laboratory



LIFE TESTS of various parts, such as the brushes and wheels, are carried on in these test racks

samples room" what is believed to be the most complete collection in the country of vacuum cleaners as they were developed from carpet sweeper days in 1860 to date. Some of the older material was obtained from the patent office in Washington. Certain developments, such as cleaner brushes, are segregated on shelves and show at a glance the genesis of the present model. For comparison with its own product, there is also a complete collection of competitive types, so that the staff has a thorough knowledge of its entire field. All exhibits are tagged and described, and photographs of them are filed for patent and checking purposes.

Money spent on an engineering department of this kind tends to insure continuous and profitable business for many years to come. The company is rapidly accumulating a fund of information on fundamental cleaner design that will be invaluable in the future.

▼

Weight Constants for Various Shapes of Rod Stock

J. K. Olsen
Chief Draftsman,
Stewart-Warner Corporation

A SERIES of constants may be used to advantage in determining the weights of rods, bars, and shapes. These constants are the direct proportional ratio between a circle of any given size and the various inscribed and circumscribed figures corresponding to the stock cross-sectional shape. To determine the weight of stock per foot for any one of these shapes, the diameter of the circle about, or inside of, which the figure is circumscribed or inscribed is first obtained. The next step is to find the weight per foot of rod of the desired material and the previously obtained diameter. This is obtainable in various tables and handbooks. The final step in computing the required weight is to multiply the weight per foot of material by the constant given in the accompanying table for the figure. The product of these two items will be the weight desired. The constant for a segment of a circle is 0.090845, when one line of an inscribed square is the inner limit of the segment. When a square is circumscribed about a circle to form a fillet or spandrel, the constant is 0.0683. The constant for an oval equals the long diameter divided by the short diameter.

Weight Constants for Various Bar Stock Shapes

Figure	Constant	
	Inscribed Polygons	Circumscribed Polygons
Equilateral triangle	0.4139	1.6540
Triangle (3 sides)	0.31831	1.8553
Square (4 sides)	0.63662	1.27324
Pentagon (5 sides)	0.75683	1.1578
Hexagon (6 sides)	0.82698	1.1026
Heptagon (7 sides)	0.87102	1.0730
Octagon (8 sides)	0.90032	1.0548
Nonagon (9 sides)	0.92072	1.0427
Decagon (10 sides)	0.93550	1.0342
Undecagon (11 sides)	0.94648	1.0281
Dodecagon (12 sides)	0.9549	1.0235

With 46 parts the customer can make 4,750 different lamps

The Customer is the Designer

How the Udezine lamp was engineered

By L. C. DOANE

Chief Engineer, The Miller Company

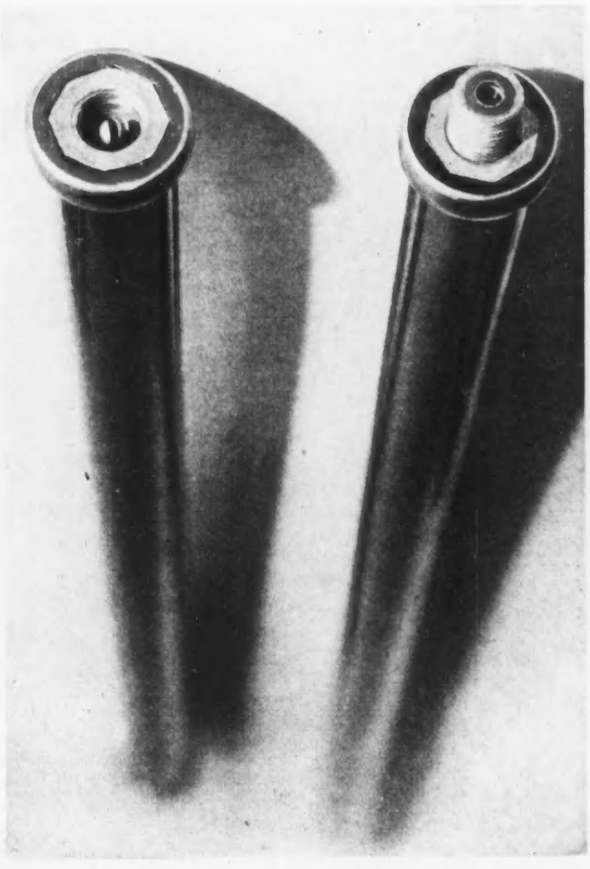
PORTABLE lamps, as formerly manufactured, were unsatisfactory in many ways. They were expensive to produce because of the great diversity of styles, costly to ship and package because of their size, and never fully satisfied the buyer, as they were the result of the manufacturer's taste in lamps and did not allow for variation of personal preference. This last item was an important one, as retailers were obliged to carry an enormous stock to meet the great diversity of taste common to the buying public.

Artistic design is an outstanding feature in a household article, and is nearly always a question of personal preference. Designers employed by the manufacturer might devise a lamp that seemed perfect to them, but meet with no enthusiastic reception from the buying public, each member of which had personal preferences as to the arrangement or design of the component parts of the lamp. But the lamp was fixed in the style as originally built; it admitted of no change.

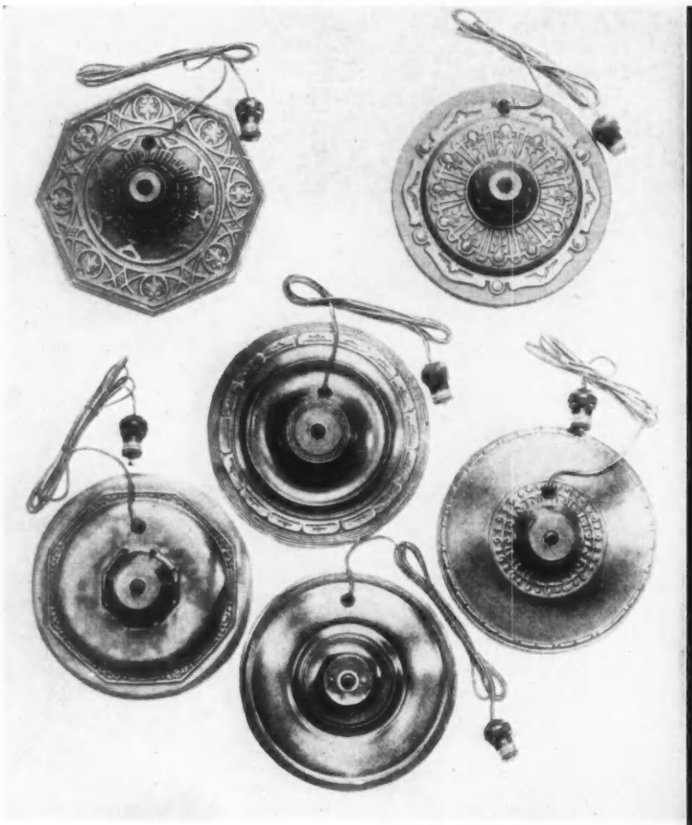
These were the problems presented to the engineering staff of The Miller Company at a time when it was realized that portable lamps were coming into greater vogue and had enormous sales advantages over set fixtures if individual style ideas could be met. As each lamp was built of parts constructed for that particular style of lamp, it was actually a custom-built lamp. This method of manufacture was wasteful, and work was begun on design of a lamp that would have interchangeable parts to facilitate economical production.

About this time a chain-store buyer came to the factory looking for lamps that could be sold for less than one dollar. As the metal alone in a high-grade lamp cost about double this amount it was obviously impossible to produce at that price, but the interchangeable units being now in production the customer ordered a large shipment of lamps in parts, each part to sell under one dollar. This was done and the lamps met with a high degree of consumer acceptance, despite the fact that each customer was required to use tools to assemble the lamp and to wire it after assembly.

A vast new merchandising field was thus opened for lamps that formerly were sold only in a high-priced field. But the engineering department saw still another broad field if the better-type lamp could be made to assemble without the use of tools and without having to "snake"



POSITIVE electric connection without the use of wiring was an important feature of the design



LAMP BASES were limited to 14 that would meet nearly 100 per cent of customer requirements

the cord of the lamp through the finial, tubing, column, and base.

The engineers could visualize what was needed, an automatic connection that would make contact immediately as each part of the lamp was assembled, without the use of tools. But the exact, perfect solution of the problem eluded them a long time.

That it took so long for the automatic contact to be developed is readily appreciated when the difficulties which had to be overcome are enumerated. There was first the problem of a contact that would be absolutely automatic, a connection made as the various parts of the lamp were screwed together. Next came the question of developing a contact that would be fool-proof, that would resist any tampering by unversed amateurs of electricity.

A lamp was now made available to the consumer that would be the product of his or her tastes, a lamp that could be constructed for approval on the sales floor from parts the consumer selected. It was appropriately named the Udezine lamp. Lamp parts for replacements could now be bought as they were desired, making several styles of lighting available in only one lamp. The lamp buyer, who would tire of one style could now convert the lamp to other styles or types of lighting as often as she wished to purchase a new type of finial and substitute it for the old, an operation requiring but a few moments. This naturally opened up a field of continuous selling of additional parts to customers who liked to change styles in their homes without the expense of buying complete new lamps. From the dealer's standpoint the new design enabled him to reduce his stocks of lamps. He had only to make a few changes in his assembled display lamps to be in accord with any new style that would be evolved.

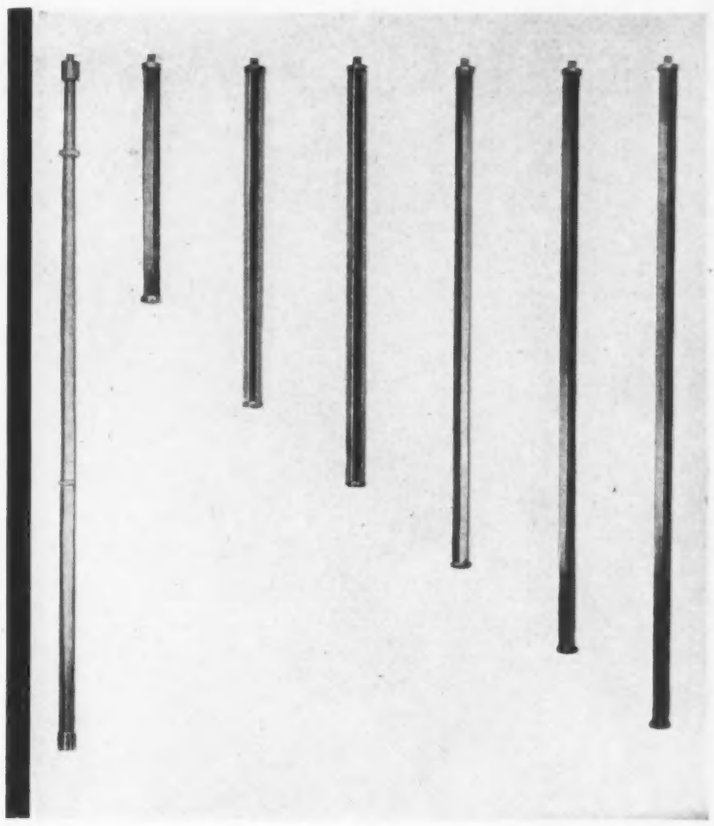
The possibilities of combinations of parts to make different styles of lamps immediately presented itself as a problem to the engineers. With 10 different bases, 11 columns, and 4 bridge-style arms it is possible to make 440 different bridge lamps, and by adding just one more piece, a "companion tube" it was possible to add another 440 adjustable lamps. These 880 lamps could then be multiplied by the number of finishes ordinarily called for, which if assumed to be ten, would be 8,800 nominally different lamps. This procedure could be multiplied indefinitely.

It was finally decided to standardize for the present on 46 unit parts, consisting of 10 floor bases, 4 table bases, 11 column pieces, 1 sliding tube, and 20 attachments. With these 46 parts a total of 4,000 major combinations of different floor lamps and 750 table lamps could be made in addition to a large number of "freak" combinations. It was then determined to

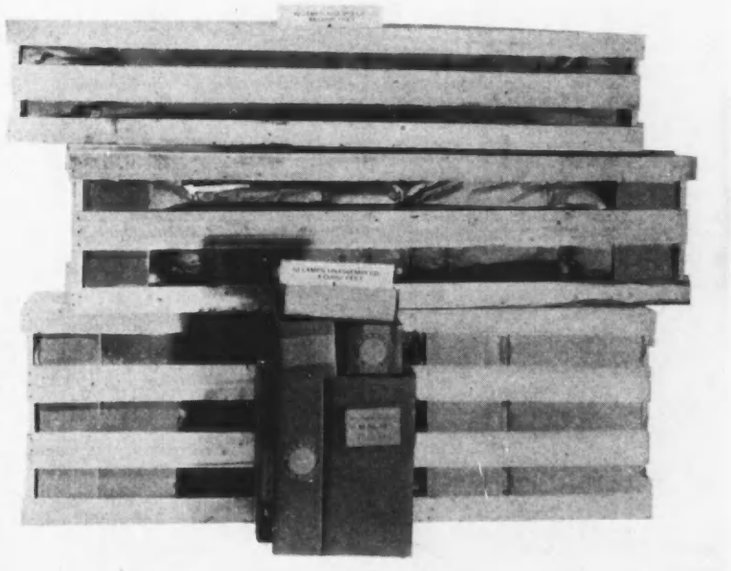
TYPICAL assortment of parts. From them can be made several different types of lamps

standardize on two finishes—bronze, and Birmingham bronze, and in four base metals—bronze, iron, pewter, and Miller metal. This standardization was the outcome of a close study of sales records and of field inquiries. By far the greatest percentage of present demand in lamps falls within this sphere. It was further decided to fill any orders for special designs or finishes, but to charge extra in order to make the "special" customer stand the expense of interfering with production schedules.

Having determined these fundamental considerations the designers proceeded to design the range of lamps to meet the widest customer acceptance. The artistic designs were made by the company artists with appearance as the first consideration. These designs were then broken down by the lamp designers in order to work in standards of length and diameter for tubing. Steel tubing was adopted for the interior



TUBES are standardized for economic production on automatic machines



A DESIGN is not complete until it is in the hands of the customer. A redesign of packing reduced the shipping space 90 per cent

frames in order to obtain mechanical strength in the small space allowed within the artists' lines on the outside forms. The connections are $\frac{1}{8}$-in. pipe thread with all threads and connecting parts copper plated to protect against corrosion. The bases, columns, and arms are cast in permanent molds or in sand depending upon the design. Tubes and fittings were designed to be run in quantity in automatic machinery. Some of the fittings and attachments are molded in the phenolic resinoids. Glass shades in portable lamps are limited to the "torchiere" type and to indirect lighting effects, but a vast assortment of styles are available in parchment shades. The design of arms and columns therefore had to conform with current styles in these as they were found on the market.

Formerly, 40 per cent of the cost of lamps was embodied in the shipping costs which included crating, carting, and freighting assembled lamps. The designers, therefore, saw a further opportunity to cut this expense to a small fraction by designing packages that would take convenient unit shipments of parts instead of the former bulky packages. Cartons were designed that would take ten units in such a way that a shipment of 10 lamps unassembled will now occupy only 3 cubic feet of space, whereas 10 assembled lamps would require 29 cubic feet for shipment. The saving in shipping costs was enormous, besides actual saving in shipping time, and brought credit to the designers.

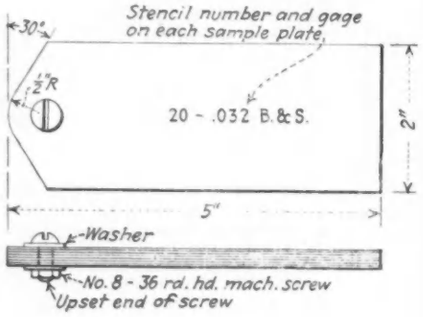
COMMENT AND SUGGESTION

Sheet Metal Sample Plates

By J. Roland Henhoeffer
Naval Aircraft Factory

IN designing sheet-metal parts a discussion arises very often in the engineering department as to the gage of the material to select for the particular job, and whether the material selected from ordinary judgment is too light or too heavy.

A handy collection of samples of sheet metal can be obtained in the



shop from time to time, and will be found useful in visualizing the selection made, because the designer can examine the metals as to thickness and stiffness.

The accompanying sketch will show the manner in which the samples may be arranged for use, and how the numbers and gages can be stenciled on each sample plate in consecutive order.

(Editors' note.) Various producers furnish sets of samples made up in somewhat similar fashion. For example, the Spaulding Fibre Company, Inc., make up sets of fiber sheets, while the Scovill Manufacturing Company have small plates of brasses, bronzes, and nickel silvers with the composition stamped on them.

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Traditions About Designing

By James A. Covington

THE editorial "Must We Import Designers?" which appeared in the September number of *Product Engineering*, partly explains why students in college almost invariably associate drafting with designing. Machine design, as taught at most of the technical schools up to the present time, consists of a few hours of design calculations and many hours of drawing. The latter becomes irksome.

As stated in the editorial, too many of our manufacturers still require their designing engineers to come up through the ranks of the drafting room. In the olden days, that was the only route possible. Designing was entirely empirical. College students still believe that to become a designing engineer they must work for years at the drawing board. This traditional conception, together with the monotonous experience in college "machine design," has given rise to the almost universal conviction among college students that designing is a "dead end" job—leaning over a drafting board all one's life.

Many manufacturers do have enticing propositions to offer to young men who wish to become designers. Some schools give really interesting courses in machine design. Both should join hands to dispel the unfavorable opinions that students have concerning designing. But it must be considered that both schools and manufacturers, as a whole, have much to do to improve courses and careers for designing engineers.

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STOP... LOOK... LISTEN...

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. . . DEVELOPING THE OLD . . .

PROBLEMS in picking the best materials are not confined to choosing between the new alloys. Even the old reliable of all construction, cast iron, is perking up a bit just now. One machine building concern is using three separate mixtures of cast iron in its machines, each being chosen for the particular function it has to perform. There is more engineering in the selection of materials now than there used to be in the whole machine.

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. . . NITRIDED SHAFTS . . .

IF the right metal is picked for a bearing, nitrided steel shafts can be run at high speed with little or no lubrication, Professor Homerberg said at the A.S.S.T. meeting in Chicago. He recommends a nickel bronze having about 80 per cent copper, 11.5 tin, 5.5 nickel, and about 3 per cent zinc. The matter of using nitriding steels for shafts in many cases, and running a glass-hard bearing surface, is worth thinking about.

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. . . FIDDLING WITH KITES . . .

"NO one has yet built an airplane. We are fiddling around with kites. We are more or less forced, whether we want to or not, to take up the subject of radical airplane design and get busy on the problem." This is the view of William B. Stout, president of the Stout Air Services, Inc., and those who know "Bill" recognize that he is looking ahead, as usual. He believes that radical development, aimed toward fool-proof machines, is needed before aircraft can hope to serve the masses as automobiles do today.

Fancy Specifications

By Joseph Bell

IN attempting to keep material specifications up to date too much detail often is added. Detailed specification presupposes an intimate knowledge of the industry that produces the material. Unnecessary detail results in paying higher prices and delaying delivery. In many cases, it also restricts competitive bidding to one or to a few concerns.

Better specifications can be prepared by close co-operation with the basic industries producing raw materials. The engineering societies have done a great deal in simplifying and standardizing specifications. Many standard material or product specifications are furnished by these societies. These should be used, of course, whenever applicable, unless a better or simpler specification will result in getting a satisfactory material at a more favorable price. The Federal

Specifications Board issues master specifications which are mandatory on all government departments and are the result of close co-operation with industry, and of exhaustive tests which cannot be duplicated by the average manufacturer without undue expense. In many cases these standard specifications are not wholly satisfactory, but result in securing a superior product at a moderate price.

Only in cases where investigations have proved that a new or special material is highly desirable should an "original" specification be employed. In general, avoiding "original" specifications wherever standard commercial specifications are suitable, will result in lower costs and the elimination of delays and controversies.

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Where's That Draftsman?

By Eli Smith

ALTHOUGH shop contacts for draftsman are advantageous, it is annoying to seek a particular draftsman at his board for some urgent information, only to find that he has disappeared to parts unknown. Where is he and when will he return? Having a secretary telephone to likely shops in order, is time-consuming and imposes upon the shops.

A simple alternative is a small dial, showing various shop names. It can be drawn in a few minutes, blueprinted, glued to a board, and a small arrow cut out of thin sheet metal can be mounted upon a nail through the center of the dial. By merely having the draftsman set the arrow so that it points out his destination before he leaves, a glance at his board shows where he can be located.

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Incentive for Designers

Charles H. Willey
Hoyt Electrical Instrument Works

I HAVE made it a point to clip out good meaty articles from my various trade journals, indexing and filing them away for reference, and once in a while I run through the files to obtain inspiration and help in my work. While doing this recently I ran across an editorial, published in the December 12, Product Engineering number of *American Machinist*, which struck an important note, in that the effectiveness of designers is curtailed by the lack of recognition.

The editorial mentioned that in the great majority of companies patents allowed for the ingenious work of design are signed over to the employing corporation, by agreement, and that the man responsible must be content with his generally inadequate salary. Perhaps he is of sufficiently professional mind to be above incentives that would add to his own comfort and security, but more probably he is not.

This editorial ought to be taken by some kind-hearted old philanthropist, reprinted and distributed in the field of industry, that those responsible for such a condition in this advanced age of co-operation and fair play between employee and employer might read it and awaken to its message.

An occasional pat on the back is nice, but a more substantial recognition is needed. Of course some will say that the designer who is well paid ought to be satisfied, because it is only possible for most of them to invent and make good designs of products because their employers provide the tools, the material, and the problems for them to solve. But most of our greatest strides forward in industry have been the results of the rewards that were known to be awaiting the success of solving difficult problems. *Product Engineering* can do much from time to time in its columns to make better conditions for designers and engineers through open minded discussions.

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Ditto Versus Blueprints

By J. R. Hillyer

REPRODUCTION of sketches may be made by using a Ditto pencil for the original and taking copies off on a gelatine duplicator. Naturally the method is not suitable for very fine detail, but where this is not required, the method gives very presentable reproductions and has ordinary blueprinting beaten for speed and economy, as no developing or drying is required.

The appearance of the reproduced sketch is very pleasing, and also the purple lines and white ground are more legible than a blueprint. This method has been particularly successful where not more than about five copies of the drawing are required, and, as stated, when the detail does not involve fine lines.

. . . EXAGGERATABILITY . . .

A LINE of kitchen utensils made of one of the chrome-nickel alloys and sold by a well-known New York department store evidently has physical characteristics which have, until the issuance of a recent circular, been unknown to engineers. Among the claims made for the utensils are that they are "twice as strong as steel," "never chip," and "reduce fuel costs." These statements pale to insignificance, however, beside this one: "Tensile strength eliminates dissolving and pitting." Product manufacturers would do well to see how agents treat their babies when they reach the market.

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. . . 500,000 LB. OF PLASTICS . . .

WESTERN ELECTRIC now is making a more compact telephone terminal box at the rate of a million a year. It weighs eight ounces. The material used is a phenolic resinoid instead of stamped metal.—Why?—Well, the manufacture is almost complete in a single operation. Eight boxes are made simultaneously in one mold. No finish need be applied, yet the product has fine appearance, will never corrode, and has no magnetic effect. And it's virtually indestructible. — Reasons enough! The plastics are coming along nicely, thank you!

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. . . SYNTHETIC STRETCH . . .

SYNTHETIC protection against Professor Sykes' synthetic rain seems about to be achieved with the announcement that Bureau of Standards chemists are meeting with success in their efforts to find a rubber substitute. Following Germany's lead during the late war, there appears a definite possibility that home-made rubber may yet be something beside a stretch of the imagination. This material, which at one time no designer gave a snap about, is becoming increasingly important in machine construction. For example, Chrysler cars incorporate 35 to 45 lb. of rubber aside from that used in tires, Fords about 20 lb., and Chevrolets about 12 lb. Engine and spring supports, insulation, coverings, door strikers, and similar items account for the total. Rubber use in other products is likewise increasing.

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. . . THE SPECIALIST . . .

IT may be a great source of pride to sit back and say: "Sure, we make everything here from soup to nuts." But everywhere the fact is apparent that the engineer who doesn't design commercial parts and units into his machine is almost invariably losing money for his firm. Let's be honest with ourselves! Can a plant, for example, in which the main production problems are not bearings, cast bronzes economically and get the uniform jobs that would result from the bar castings bought from specialists?

PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

November, 1930

. . . If we knew that the manufacturers of materials, bearings, and many other things which go to make up our machines, had reached the end of all possible improvement, then we would be in that very same situation . . . — F. E. GARDNER, *Vice-president in Charge of Engineering, Gardner Machine Company*

The R-101

LAMENTABLE as was the loss of valuable lives when the R-101 fell, the loss of prestige to the whole industry is also great. The lighter than air type of airship has been lately looked upon as the hope of rapid air passenger transportation, but the public will not gain confidence and the industry will not advance to the position where it ought to be until the menace of such accidents as happened to the R-101 and the Dixmude is removed.

The exact cause of the wreck of the R-101 may never be known, but some facts are a matter of record. Drastic changes were made after the building of the ship had been almost completed. Oil engines were substituted for gasoline engines. Another section was inserted in the hull of the ship to obtain the increased lifting power necessitated by the greater weight of the oil engines.

Any such material changes in an engineering design affect the stresses and rigidity throughout the whole structure. A patched job can never be as good as an unaltered one. Last minute engineering changes may not have been the cause of the R-101 disaster, but the construction of the ship cannot be considered a first-class engineering job. In view of the known dangers of the lifting gas used, the wisdom of the long trip may be open to question. Is it another case of engineering being "the goat" to expediency?

No Birds in Last Year's Nest

WHEN depression strikes the sales end, the time for the engineering department to work harder on new ideas is at hand. Many examples can be given of manufacturers who found their real "pot of gold" in products that were developed from research done during times when the plant was otherwise depressed. A questionnaire just sent out by *Product Engineering* reveals the notable fact that eighty per cent of the firms furnishing the information gave more consideration to new designs this year than during last year. Ninety-eight per cent of all these firms worked on improved products during 1930, and ninety-nine per cent say that they intend to work on the devolopment of new products during the next six months. A further analysis of the statements made by these manufacturers indicates that seventy per cent of them extended their present lines, and sixty-eight per cent also developed entirely new products during the present year.

Any manufacturer who is sitting back waiting for better times, and who is expecting to make those better times with his last year's product, is not likely to encounter even good times. His competitor may be found to have accumulated the whole bag of tricks.

Now is the time to look the product over with the critical eyes of the engineers—Is it doing mechanically what it should do, and in the best way? Are the most modern materials and finishes being used in its construction? Could commercial parts, built efficiently and economically by specialists, be incorporated into the design? Finally, does a study of the product in hand suggest new and better products that can be built with the same class of equipment and skill? An honest judgment of the product in a constructive manner might show some surprising things.

A diagnosis is in order. If the executives overlook the point, every engineer in responsible charge of product development should see that the diagnosis is made. The product that will sell best with returning good times is not the one that sold best last year. "There are no birds in last year's nest," is something that applies to products that are expected to stir up new business in these competitive times.

How Specify the Color?

COLOR in product has now become so important that the design engineer cannot afford to pass over it lightly. But how is the designer going to specify a color for the product and know that it is what he wants to match other products? And how does he know that the matched color will be a match after it has been exposed to sunlight for a period of time?

From time immemorial matching of colors has been done with samples, but samples change hue, and the eyes of the inspectors vary in color perception. Moreover, two finishes of similar apparent color to the eye may vary greatly in color after a few hours' exposure because of differences in the fading qualities of the constituents of the pigments.

The photo-electric cell now comes along with the answer and points a way to a new definition of color values. With such a device in the laboratory a definite color specification can be set up and comparisons can be made that are physical and definite rather than physiological. It may not be long now before the engineer who has to view color seriously will base his specifications on wavelength rather than on fantastic names that have only indefinite meanings.

Such a method of classification will be getting down to fundamentals. It may throw a major part of the responsibility back on the original pigments and require closer specifications, but the results in the finished product should be infinitely better.

■

Leap After Looking

THAT the so-called "stainless" and other high-chromium, and the chromium-nickel steels have marked advantages in many respects is no longer open to question. In common with many other new or comparatively new materials, however, they possess some less favorable qualities that demand consideration if the good qualities are to yield commercially the advantages anticipated.

Before specifying materials in the classification mentioned, therefore, engineers should make sure that the particular grade and brand selected can be worked advantageously by the shop doing the fabrication. High-chromium steels are difficult to machine. They work-harden rapidly. Grinding and polishing involve some very real problems, as do also drawing and other operations. If annealing is required, it must be followed by a proper pickling to remove the highly abrasive scale formed.

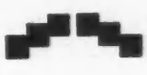
These are a few of the precautions worth noting before embarking on a production schedule. They should not deter a prospective user, for they have been observed and an answer to them found in almost countless instances. But to overlook them may prove disastrous to the fabricator and give the steel manufacturer an undeserved "black eye."

▼

New Designs for Old

A CORRESPONDENT to the New York *Times* asks why manufacturers do not construct safe gas ranges. Recently this woman had an unpleasant experience with gas when an overboiling pot extinguished the flame. More frequently, asphyxiation is caused at night, or at unusual times when someone unconsciously knocks against the knobs or a child moves them.

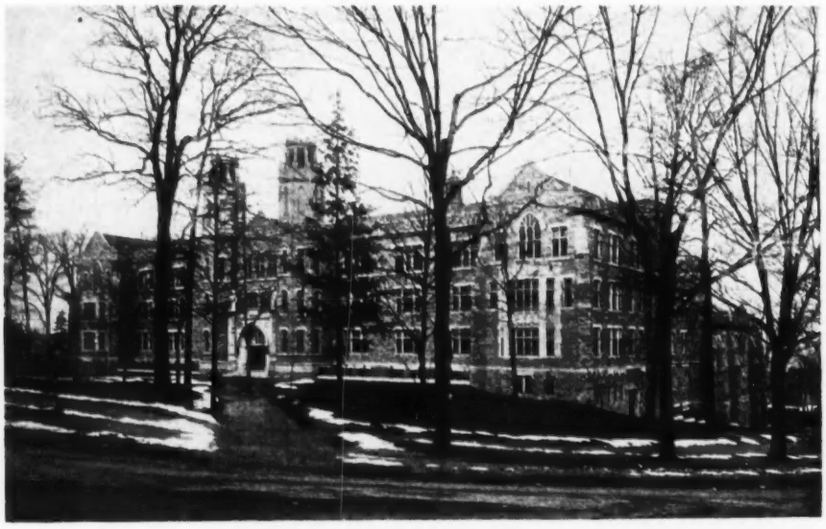
Producers of gas ranges would dislike to think that their product might be crowded out of the market by other types of ranges, especially at a time when there is so much talk of the efficiency to be obtained by converting coal into gas at large central stations for universal distribution for power and heat. But the above mentioned correspondent has struck the vital spot. Unless designers get busy and produce a range that will not endanger the occupants of a house by leakage of gas they are likely to see gas ranges go the way of many another article that could not, or would not, keep pace with consumer requirements. To find the answer should not be difficult. Why not co-operate with the thermostat makers, for example? There is apparently need here for the designers to look beyond their jobs.



WHAT'S GOING ON—

The Month In Product Design

ORANGE-COLORED PAINT on all machines, to lift their visibility and lessen the danger of accidents, is planned in the new $1,500,000 windowless factory building of the Simonds Saw & Steel Company, to be built in Fitchburg, Mass. Walls and ceilings of the structure will be blue, green, and white. All lighting will be by 1,000-watt lamps diffusing ultra-violet rays in addition to their illumination. Ventilation will also be taken care of automatically. Tests have shown that a 33 per cent increase in efficiency of workmen may reasonably be expected.

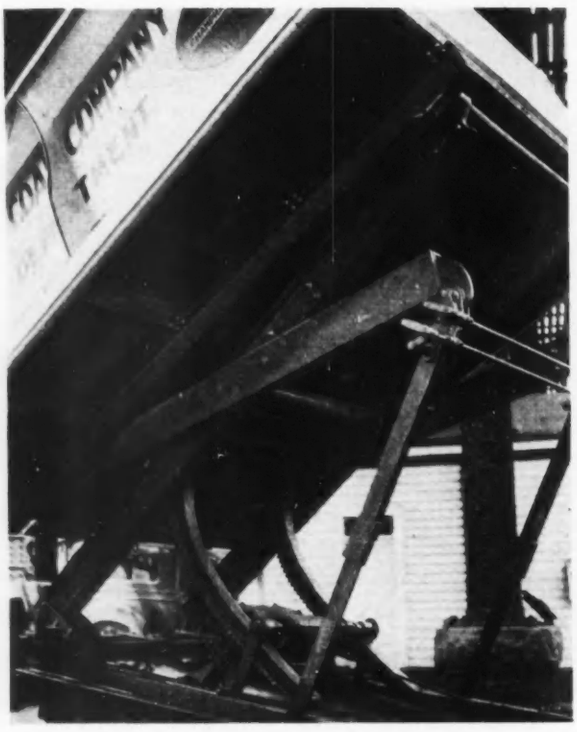


Outstanding engineers, educators, and leaders of industry participated in the exercises and conferences held Oct. 15-17 in dedicating the James Ward Packard Laboratory at Lehigh University

A COLORSCOPE for matching colors on textiles, which utilizes two photo-electric cells, is announced in *Textile World*. The machine, manufactured by the Sheldon Electric Company, is claimed to eliminate the human equation entirely, thereby preventing errors in comparison. Samples of fabric to be compared are placed in front of the cells, variations in depth of color being shown by a galvanometer in the circuit. The device not only indicates variation in color, but also the degree of variation. The deficiency or excess of the primary color which causes the variation may be determined by placing filters between the samples and the photo-electric cells.

ROAD - BUILDING EQUIPMENT displayed at the sixth International Road Congress at Washington, D. C., was of two types, that for rigid surfacing, and that for non-rigid surfacing. The Flexible Road Joint Machine Company displayed a flex-plane machine for making and sealing road joints, which presses in a steel ribbon or composition strip. The double-flanged wheels operate on steel sideforms, the inside flange being sharp to assist in edging. A high-speed cutter opens the joint ahead of the strip.

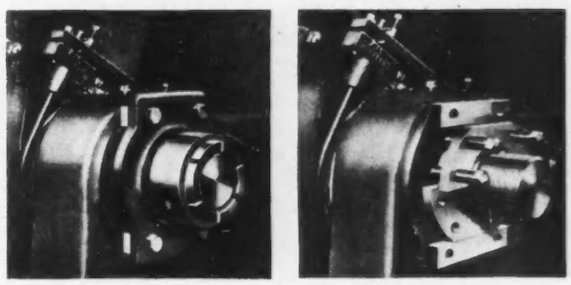
LOCOMOTIVE builders and users of locomotives in a symposium on "The Locomotive of Tomorrow," contributed interesting forecasts regarding railroad motove power of the future. As reported in the *Railway Age*, significant prophesies included train speeds up to 100 m.p.h., boiler pressures of 850 lb. per sq.in. and better fuel economy resulting from higher pressures and temperatures, and increased horsepower capacity at high speeds. All of these factors require the discontinuance of the conventional firetube boiler. Several of the speakers commented on the possibility of Diesel, steam turbine, and Unaflow engines playing a big part.



Gross weight of this aluminum alloy truck body and hoisting mechanism is 1,800 lb. less than that of the ordinary body. It has given first-class wear resistance on a Pittsburgh Coal Company truck

ELECTRIC CLOCKS proved so popular that a number of manufacturers entered the field, with the result that designers now find it necessary to redesign their products for sales appeal. The Time-O-Lamp Company is now producing a table lamp which incorporates a clock motor within the shade, the shade itself acting as a rotating dial, the pointer remaining stationary. The "Uniclok," meanwhile incorporates a lighted globe atlas above a Telechron clock motor, giving at once a novel lamp, a chronological illuminated map of the world, and an electric clock. Both lamps come in a number of base designs. General Electric has also issued an electric clock, powered with a usual Telechron motor, in a variety of new case models, including a grandfather type. Telechron's new clocks include one of satinwood with an inlay around the base, another of mahogany with a maple burl paneling, and another in black enamel with chrome finish. Hammond, meanwhile, has introduced the Gregory Calendar Clock of black bakelite which incorporates a calendar showing the day and date, operated by the motor, and timed to change at midnight.

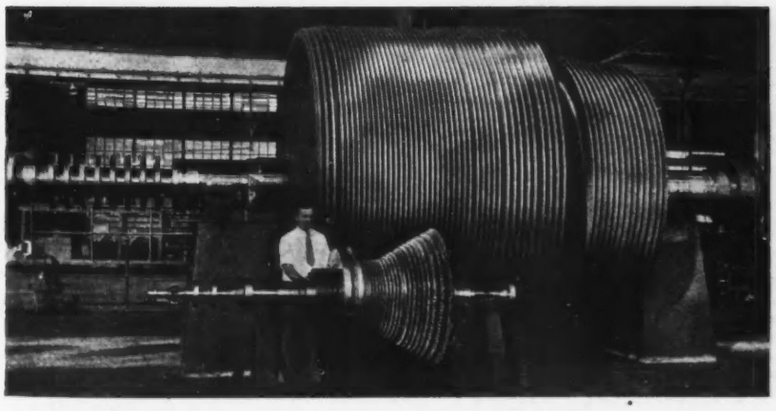
A LOW-RESISTANCE alkaline storage battery has been invented by J. J. Drumm, of Dublin, Ireland, according to *Electrical World*, which gives heavy current discharge during periods of acceleration, and a charging rate considerably in excess of any battery on the market. The battery has 77 cells, each 12x18x10 in., and weighs 6,000 lb. Cells are composed of 8 negative and 9 positive plates, positive plates being of the standard nickel-hydrate type, and the negative plates, specifications of which are secret, appearing to be a common thin sheet of metallic gauze composed of zinc and aluminum. The electrolyte is a solution of caustic potash. Watt-hours per pound of battery are given as 8 to 10, although approximately three times that output may be obtained by giving the battery boosting charges during the day's run. The battery has been used to supply power to a 13-ton railway coach having two 110-volt, 35-hp. motors. The main charge was put into the battery at a slow rate during the night and boosting charges at 200 amp. for 10 min., 400 amp. for 20 min., and 600 amp. for 10 min. were supplied at intervals, the average voltage on charge being 152 volts.



Canton alligator shears now carry a split gun-metal fulcrum-pin bearing which makes rebushing extremely simple. It is shown assembled at the left, and with the top half of the bearing being removed at right

A Glance Over the Pages—

1. *Is there a general formula for vibrating systems? p. 499*
2. *What type of motor is most general in machines? p. 505*
3. *Which factors have an important bearing on industrial wheel strength? p. 508*
4. *Can stainless steel be cast? p. 512*
5. *Why use die castings in typewriter construction? p. 513*
6. *What is gained by co-deposition of metals? p. 517*
7. *What are design problems in building an electric lamp? p. 525*
8. *Are designs in electric clocks changing? p. 533*
9. *Who is the new president of the A.S.S.T.? p. 536.*



Battleship propelling turbine spindles which deliver exactly the same horsepower—7,000. The larger runs direct-connected at 240 r.p.m., the smaller, running at 3,600, drives through reduction gearing. The former is being rebalanced at Westinghouse, the latter was built there

WASTE-HEAT BOILERS of the single-pass, three-drum type, built by the Babcock & Wilcox Company, are described in *Power*. Drums are horizontal; the upper steam drum, and the two lower mud drums are connected by bent tubes staggered and spaced closer in the rear portion than in the front to maintain the high gas velocity, thus giving better heat transfer. Vertical baffles are inserted in the rear portion to prevent gas lanes and assist in dust precipitation. Vertical arrangement of the tubes and baffles causes unusually effective dust precipitation, the dust dropping into soot hoppers made the full length and divided into a number of sections by means of vertical partitions. Multiple clean-out connections are provided on the bottom of the hopper. The inverted type of superheater used prevents dust lodging on its headers.

ELECTRIC REFRIGERATORS built by Majestic are a combination between the General Electric and the Frigidaire models. Unlike the G.E. machine, none of the mechanism is exposed above the cabinet, the mechanism being entirely enclosed above the food compartment. Like the Frigidaire, a fan is used to obtain the circulation of the cooling air around the condenser tubes.

Vertical cabinet edges are beveled. Satin chromium plate is used for latches and hinges, and the temperature regulator escutcheon plate is in harmony with them. Insulation is a combination of fiber board and "Dry Zero." Motor and compressor are hermetically sealed in a compact, 9½-in. pressed-steel housing. To eliminate vibration, a rotary pump is used, driven direct from the motor.

AIRPLANE WINGS having ribs of Allegheny metal are used in the Ireland "Privateer" low-wing monoplane, according to *Aviation*. The wings are built up of spruce spars, spruce and plywood compression struts, and the corrosion-resistant alloy. Similar construction is used on stabilizers and fins. Chrome-molybdenum tubing is used for torque tubes.

News Notes

DISCUSSION, mostly favorable to free-wheeling, followed the paper on that subject by Delmar G. Roos, chief engineer, Studebaker Corporation, presented before the Metropolitan Section, S.A.E., at its meeting in New York on Oct. 16.

Mr. Roos admitted that free-wheeling puts extra work on the brakes, but said that there is no difficulty whatever in providing ample braking capacity. He also said that no difficulties had been encountered with the type of roller clutches employed in the free-wheeling unit, and offered a strong case for the advantages secured.

A MEMORIAL to a great engineer, inventor, and industrial leader, George Westinghouse, was unveiled on Oct. 6 at Schenley Park, Pittsburgh. About 55,000 employees of the Westinghouse organization and other friends contributed to its construction. James H. McGraw, Sr., Chairman of the Board, McGraw-Hill Publishing Company, publishers of *Product Engineering*, said regarding the memorial: "The true significance of the memorial is that the spirit of George Westinghouse still lives, not only in the organizations he built, but wherever industry and engineering are found throughout the length and breadth of the world."

ADDITIONAL COPIES of *Product Engineering* reference-book sheets Nos. 2, 2a, 3, and 3a on Materials, covering material weight comparisons and recent corrosion-resistant alloys, are available for the asking.

Materials Featured At Metal Congress

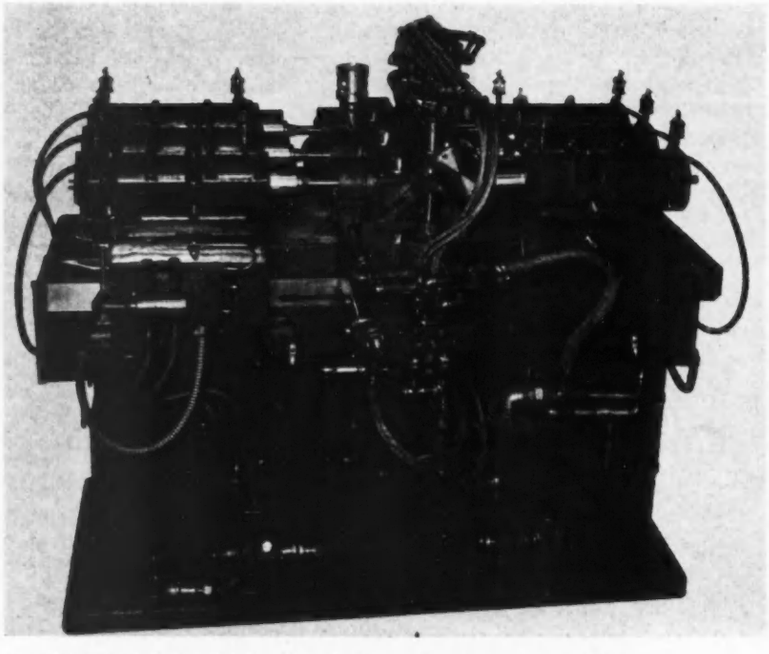
MATERIALS designed to afford resistance to corrosion, to heat, and in many cases, to wear also, were the focal point of interest at the National Metal Congress.

One of the liveliest discussions during the A.S.M.E. professional sessions followed the paper by Herbert Chase which was rewritten from his article on flange-mounted motors in the February issue of *Product Engineering* and that by J. L. Browne on "The Mechanical Design of Electric Motors as Regards Standardization and Interchangeability," condensed in this issue. Although there was some difference of opinion concerning the advantages of flange mounting, a majority of those joining in the discussion appeared to favor this type, especially if a standard flange becomes available. Statements made at this meeting indicated that rapid strikes toward the standardization of motor mounting dimensions are being taken and that at least the squirrel-cage induction-type motor, made to standard dimensions for pedestal mounting, soon will be available.

Two of the A.S.M.E. papers dealing with plastic molding indicate that products of this process, made either from phenolic or from other materials, are replacing metal in some important uses, partly on account of their good dielectric properties and partly because, in some instances at least, they come from the mold in such shape as to require almost no finishing operations.

John M. Watson was nominated for the presidency of the American Society for Steel Treating. Other nominations included Alexander H. d'Arcambal for vice-president, and B. F. Sheppard and F. B. Drake for directors.

At the metal show, chief interest centered again in the corrosion-resistant metals, the use of which is extending rapidly. There was, however, a comparative dearth of strictly new materials. Next year's congress is to be held in Boston, Sept. 21-25.



Ex-Cell-O fully hydraulic horizontal diamond or tungsten-carbide piston and connecting rod boring machine. Three roughing heads and three finishing heads have the motor rotors built into the spindles, the work-carrying fixture moving between them

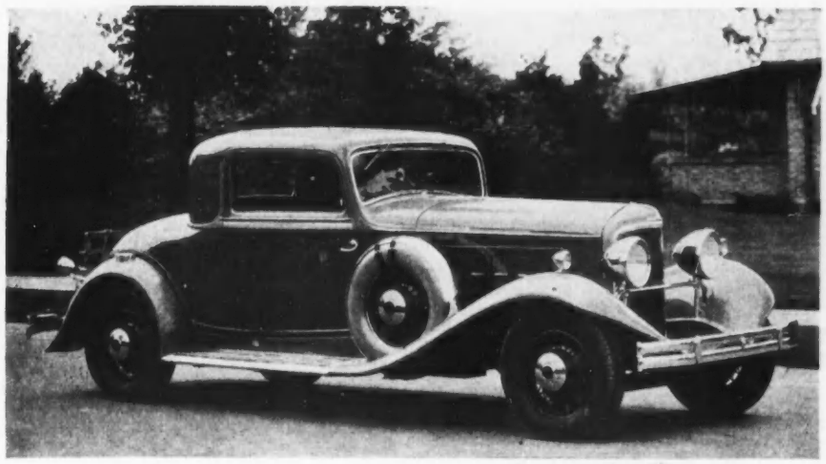
Automotive Design Trends

By Herbert Chase
Associate Editor

REO'S two new lines of eights are the outstanding automotive development of the past month. They are noteworthy, however, not so much because they are eights, for their mechanical design is not unconventional, as for the smart appearance of their new bodies. The latter are the work of Amos Northrup, chief designer of the Murray Corporation of America, which is building the bodies.

Striking effects are obtained by the use of a V-shaped radiator in combination with fenders having a deep crown, flowing lines, and a sharp inward turn at the front; a superstructure with well rounded corners and fixed sloping windshield; a rear panel which curves outward at the bottom to provide a clean and attractive cover for the fuel tank; and D-shaped windows.

A 148-in. wheelbase makes the "Royal" eight of the Reo line one of the longest cars available in this country today. All the Reo chasses, which include sixes as well as eights, have silent herringbone constant-mesh and second-speed gears. The Royal chassis is equipped with a Farval centralized lubricating system.



One of the new Reo cars with Murray body

No striking innovations characterize the four new Nash models which include two entirely new eights, but they incorporate features which are new to Nash designs, such as a gearset with helical constant-mesh and second-speed gears, light drilled steel connecting rods with aluminum alloy caps, and rubber-cushioned clutch plates. All three eights, including the two twin-ignition valve-in-head engines and a lower priced L-head job, have nine-bearing crankshafts, and the chasses have Bijur centralized lubricating systems.

Although some distance in the future, so far as production is concerned, car designs with rear engine mounting continue to excite keen interest in progressive engineering quarters. There is increased talk also of chasses with independent wheel springing. Better facilities for oil cooling and silencers for engine intakes are among the minor items attracting favorable attention.

With production approaching its normal seasonal low ebb in automobile plants, prices extremely low, and competition severe, it appears inevitable that new departures in construction will receive more consideration in coming months than they have before in many years.

Indications point to new models in the Chevrolet, Hudson-Essex, Pontiac-Oakland, Lincoln, and several other lines. There is the usual speculation regarding a new Ford model, but no definite information concerning anything more than minor refinements. Wheels with 17-in. rims, some of those on light cars being of the full-drop or semi-drop type, are the coming vogue, the change from 19-in. diameter being predicated largely upon improved appearance.

Studebaker has found it expedient to extend the use of its free-wheeling gearset to lower-priced models, and General Motors is expected to apply its Synchromesh gearset to cars in lower price scales than the three larger Buicks. Some cars now are fitted with electro-magnetic fuel pumps placed in the fuel tank. This is to avoid the trouble from vapor-lock occasioned by other fuel-feeding means when volatile fuel is used in warm weather.

According to the Duco Color Index, black now leads in popularity, to judge from the volume of lacquer consumption among automobile manufacturers. Next in color are the various shades of blue, brown, green, grey and maroon. A year ago the order read: blue, brown, green, black, grey, maroon.

The Business Outlook

Business is bearing up as well as can be expected under the weight of the wave of uncontrolled deflation which financial fatalism and lack of business statesmanship in this country let loose upon the world in the third quarter. . . . There is a marked shortage of bear food in this week's crop of statistics, and signs multiply indicating that business as a whole is not getting worse and is making definite improvement—too slow to warrant any high hopes of quick recovery this year, but steady enough to justify those looking and planning ahead for next year. . . . Our index has risen again, for the fifth consecutive week, from 87.1% to 87.5% of normal, reflecting chiefly continued expansion in general trade and a level of building sustained above seasonal expectations. . . . Increased consumption of electric power in manufacturing during September, with some gain in employment and payrolls, indicates a fair seasonal resumption of industrial activity.
—*The Business Week*, Oct. 22.

News of the Metal Markets

COPPER, at 10c. on Oct. 18, the lowest price in 34 years, has increased its demand considerably in the electrical industry during the past month, much of the buying being for future use. Among the big orders placed was one for 12,000,000 lb. by the Pacific Gas & Electric Company, the entire order to be delivered in the form of wire. Other consumers, including the brass manufacturers, seem interested, but are refraining from making large forward purchases because of the uncertain business outlook, according to *Metal & Mineral Markets*. Export business is fair, and this, coupled with the electrical purchases, seems to indicate that the price will go no lower in spite of increasing September stocks. Prices of copper-alloy products have taken a sympathetic drop.

LEAD is one of the several metals not so lucky as copper, for its price has suffered further declines, reaching 5.2c. on Oct. 16. Purchases are, however, holding up in fair volume, largely as a result of the hand-to-mouth buying tactics of purchasers for the past several months. Lead consumption in this country has been fairly stationary during the past five months at around 48,000 tons a month, though present sales are mostly to corroders and cable demand is slack.

ZINC settled on Oct. 16 to around 4c., St. Louis, a decline of 25 points for the week, which made its price the lowest in 29 years. The tonnage of metal sold was moderate, though producers are taking a more aggressive sales attitude. Galvanizers and other consumers are operating on reduced schedule, consequently show little interest. Production is tending downward, but not at a rate to bring about a turn for the better for some time to come. This factor is the principal source of price weakness.

TIN broke to the lowest price in 28 years recently, showing a slight recovery to 25c., New York, on Oct. 15. Consumers, attracted by the low prices, purchased a good amount for current and future use. Further curtailment of production has been announced, and the Tin Producers' Association claims to have the situation well in hand. This may result in a price up-turn in the near future.

IN THE SPOTLIGHT—

J. M. WATSON, metallurgical engineer, Hupp Motor Car Corporation, Detroit, has been nominated as president of the American Society of Steel Treating during 1931. Mr. Watson is at present vice-president of the Society and served as treasurer from 1928 to 1930.

WILLIAM F. AUG, previously airplane designer with the Keystone Loening Aeronautical Company, New York City, has joined the Texas Company, Bayonne, N. J., as a mechanical engineer in anti-knock research.

GEORGE H. AUPPERL, for the past two years consulting metallurgist for the Tobatta Foundry Company, Tokyo, Japan, has returned to this country. Mr. Aupperl was for a number of years with the National Roll & Foundry Company.

ALBERT E. BERDON, formerly consulting engineer of East Orange, N. J., is now serving as research engineer for the Antioch Industrial Research Institute, Inc., at Antioch College, Yellow Springs, Ohio.

JOHN A. BINDER, formerly in charge of the experimental laboratory of Durant Motors, Inc., Detroit, has become an experimental engineer with the Continental Motors Corporation, also of Detroit.

PROF. ELIHU THOMSON, director of the Thomson research laboratory of the General Electric Company at Lynn, Mass., was recently guest of honor at a testimonial dinner tendered him at the New Ocean House in Swampscott, Mass., on the completion of 50 years' service.

ROBERT J. BROEGE, previously chief engineer of the Diesel-engine division of the Buda Company, Harvey, Ill., has become vice-president and general manager of the International Engineering Corporation, Chicago.

A. H. D'ARCAMBAL, consulting metallurgist and sales manager of the Pratt & Whitney Company, Hartford, Conn., was nominated as vice-president of the American Society for Steel Treating during 1931. Mr. d'Arcambal has been chairman for some time of the sub-committee on relation of design to heat-treatment.

ROY E. COLE has resigned as chief engineer of Durant Motors, Inc. Until two years ago he was with Dodge Brothers as chief engineer.

GEORGE W. DEBELL was recently appointed as head of the stress analysis, weight control, and static test departments of the Fairchild Airplane Manufacturing Company, Farmingdale, N. Y. He was previously with the Aviation Corporation.

M. HAMON, automotive engineer with the Shell Eastern Petroleum Corporation, New York City, has been appointed assistant manager in the aviation department.

John M. Watson

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Elihu Thomson

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A. H. D'Arcambal

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CHARLES L. LAWRANCE, who developed the Wright Whirlwind aircraft engine, has recently organized the Lawrance Engineering & Research Corporation, with offices at 227 E. 45th St., New York City. He will remain vice-president and director of the Curtiss-Wright Corporation, although his new organization is to be entirely independent of other aviation interests.

LEROY F. LEGROS, former checker in the engineering department of the Hupp Motor Car Corporation, Detroit, has become assistant designer with the Muncie (Ind.) Products Division of General Motors.

DR. LLOYD WITHROW, W. C. LOVELL, and T. A. BOYD of the General Motors Research Laboratories described details of the new method and apparatus for studying the combustion wave in an engine at the meeting of the American Chemical Society in Cincinnati during the latter part of September.

G. S. VON HEYDOKAMPF has been appointed research engineer for the Southwark Foundry & Machine Company, Philadelphia. He has been engineer of test for the Babcock & Wilcox Company, Bayonne, N. J., since his arrival about four months ago from Brunswick, Germany, where he was assistant instructor in the City Technical High School.

JAMES F. VICKERS, former layout draftsman with the Fokker Aircraft Corporation, Hasbrouck Heights, N. J., has become a layout draftsman and designer for the Aircraft Improvement Corporation, New York.

W. R. STRICKLAND recently resigned his post as assistant chief engineer of the Cadillac Motor Car Company, Detroit, to regain his health.

DELMAR G. ROOS, chief engineer of the Studebaker Corporation of America, spoke on free wheeling at the Oct. 16 meeting of the Metropolitan Section, Society of Automotive Engineers. The design features of the free wheeling principle were discussed in the August issue of *Product Engineering*.

W. G. RETZLAFF has become an engineer with the General Motors Truck Company, Pontiac, Mich.

LEMUEL PORTER, who has been drafting foreman for the Curtiss Aeroplane & Motor Corporation, Garden City, N. Y., has become fittings designer for the Sikorsky Aviation Corporation, Bridgeport, Conn.

JAMES W. OWENS, director of engineering of the Welding Engineering & Research Corporation, 25 W. 43rd St., New York City, was recently awarded the Samuel Wylie Miller medal of the American Welding Society "for his many contributions to the art of fusion welding."

P. A. MCCUNE has become director of research and treasurer for the Welding Engineering & Research Corporation, 25 W. 43rd St., New York, N. Y., which was recently formed. JAMES W. OWENS, formerly welding aid for the Bureau of Construction & Repair of the U. S. Navy, has resigned as director of welding at the Newport News Shipyards to become director of engineering and secretary of the organization.

H. J. FRENCH, metallurgist of the development and research department, International Nickel Company, Bayonne, N. J., was awarded the 1930 Henry Marion Howe gold medal for the best technical paper published in the "Transactions" during the year, at the annual business meeting of the A.S.S.T. His paper was "A Study of the Quenching of Steels," a 173-page article.

R. F. LA MOTHE has become chief engineer for the John C. Hoof Company, Chicago.

DR. ING. A. NADAI, physicist of the Westinghouse Research Laboratories and former professor of Applied Mechanics at the University of Göttingen, Germany, recently described some of the results of his researches before the American Society for Steel Treating at its 12th annual meeting in Chicago. During the last ten years Dr. Nadai has had published many technical papers, chiefly on the theory of plasticity and the mechanics of the plastic state of metals.

CHESTER S. MOODY, superintendent of the Killefer Manufacturing Corporation, Los Angeles, has become metallurgical engineer with the Northwest Engineering Company, Green Bay, Wis.

AMOS E. NORTHRUP, chief designer of the Murray Corporation of America, is credited with the design of the new Reo Flying Cloud body.

E. S. MARKS of the H. H. Franklin Manufacturing Company has been nominated as vice-president of the Society of Automotive Engineers, representing passenger-car engineering. John A. C. Warner, now secretary and general manager of the society, was nominated at the summer meeting to occupy this office.

James W. Owens

H. J. French

A. Nadai

Amos E. Northrup

CHARLES A. LYNCH, formerly manager of engineering and sales of the Fort Pitt Steel Castings Company, McKeesport, Pa., has been appointed vice-president and general manager of the Foote Company, Inc., Nunda, N. Y.

HANS W. LINDEMANN, designing engineer for the Illinois Steel Company, Gary, Ind., recently became identified with the Nationale Automobil Gesellschaft of Berlin, Germany, in the same capacity.

MARVIN E. LICKERT, formerly layout man of the DeVilbiss Manufacturing Company, Toledo, Ohio, is now engaged in design work for the Surface Combustion Company, also of Toledo.

DR. GEORGE W. LEWIS, director of aeronautical research for the National Advisory Committee for Aeronautics, was appointed vice-president of the Society of Automotive Engineers recently to represent aircraft engineering. Dr. Lewis fills the unexpired term of office of the late Chance M. Vought.

RUDOLPH R. GRANT, who recently relinquished his post as president and chief engineer of the Dayton (Ohio) Airplane Engine Company, has become a consulting engineer in Dayton.

MAURICE L. KERR was recently appointed chief engineer of the Brockway Motor Truck Corporation, Cortland, N. Y. He was formerly chief engineer of the Indiana Truck Corporation, Marion, Ind.

HUGH A. JOHNSON, formerly assistant engineer with the Hupp Motor Car Corporation, Detroit, has accepted a position at the Olds Motor Works, Lansing, Mich.

JU HSUN HOU, engineer in the automotive division of the Chinese Manufacturing Company, Tientsin, China, has become assistant engineer in the technical department at the Mukden (China) Arsenal.

D. C. HEITSHU, assistant agricultural engineer in charge of farm power and machinery research at the Virginia Agricultural Experiment Station, Blacksburg, Va., has become associated with the engineering department of the J. I. Case Company, Racine, Wis.

ENRIQUE SUAREZ DEL REAL, metallurgist for the National Cartridge Company, Monterrey, Mexico, has been visiting various plants and metallurgical laboratories during a trip through the United States.

NEW MATERIALS AND PARTS

AND

✦ ENGINEERING EQUIPMENT ✦

"Automatic" Time-Cycle Contactors

AUTOMATIC operation of various processing equipment can be controlled by means of the time-cycle contactors developed by the Automatic Temperature Control Company, Inc., 34 E. Logan St., Philadelphia, Pa. Such operations may include automatically advancing the load in a continuous type furnace, automatically timing material being heated or electro-plated, automatic lubrication, automatic operation of hydraulic presses, and many others. Contactors to meet these varied demands may be classified under two general groups: (1) Cycle repeating contactors, designed to repeat periodically the cycle so long as the line switch is closed, and (2) cycle stop contactors, designed to start from a push-button switch, run the time-cycle set, and stop until the starting switch is again actuated.

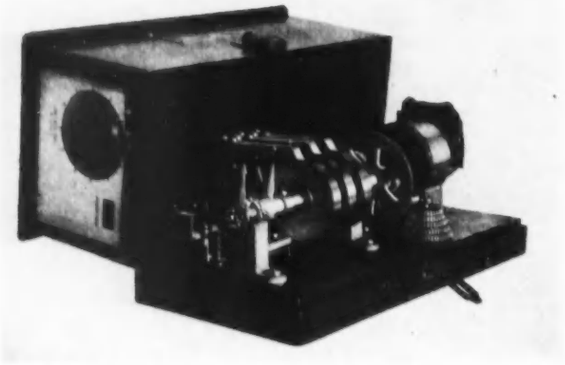


Fig. 1—"Automatic" Time Cycle Contactor designed to handle three contacts per cycle in desired sequence. The cycle may vary from a few seconds to several days

An example of the cycle stop type contactor is given in Fig. 1, this particular device being designed to handle three contacts per cycle in desired sequence. Accurate timing and necessary power for operation are obtained from a small synchronous motor, geared to the desired time requirements. Change gears permit altering the time of the cycle. One cam is pinned to the cam shaft, but the others are held in spring tension and are adjustable in relation to each other within the time of the cycle. Provision is made for shortening or lengthening the time of contact per cycle, and where necessary contacts can be provided of a type to make and break their circuits quickly. Progress of the cycle is shown by an indicator arm, which travels around a graduated dial. The number of operations in a given time may be noted readily as a totaling counter is tripped in each cycle. Units of this type have been built with 11 contact disks and with a cycle of 96 hours, while others have been built with a cycle of only a few seconds.

Another cycle stop contactor is shown in Fig. 2, but this model does not require change gears to alter the time of the cycle. Changes are made easily and quickly by means of an adjusting knob outside of the instrument case. The zero adjusting screw permits setting the lower contact, while the adjusting knob above is used to set the upper contact for any desired elapsed time within the dial range of the unit. Power and means for accurate timing are obtained from a small, double-field synchronous motor, which moves the elapsed time contact arm clockwise or counter-clockwise, depending on which of its field coils is energized. This unit is built in both the cycle stop and the cycle repeating types. The cycle stop type has a reversing switch mounted on the instrument case, but where desired, this switch can be located at a distant point.

The extension lever at the lower left-hand corner of Fig. 2 is designed for operation of the reversing switch. This lever is normally held in a raised position by means of a spring, thus throwing the motor line switch to "off" position. Placing the work in position for treatment mechanically pulls down the lever arm and throws the line switch to the "on" position. This energizes one winding of the motor, so that the elapsed time contact arm, starting from zero, travels clockwise for the time cycle set. Upon completion of the cycle, contact is made to operate a signal, or where desired, a motor operated controller. The latter can be arranged to remove the work automatically at the end of the cycle and in so doing the lever arm is pulled up by the spring, thus throwing the motor line switch to the "off" position. When the next load of work is placed in position, the lever arm is again pulled down, but this time energizing the other winding of the motor, so that the elapsed time arm travels counter-clockwise for the same time period, making contact at the zero position of the scale and repeating the cycle or the automatic removal of the work. Standard full-

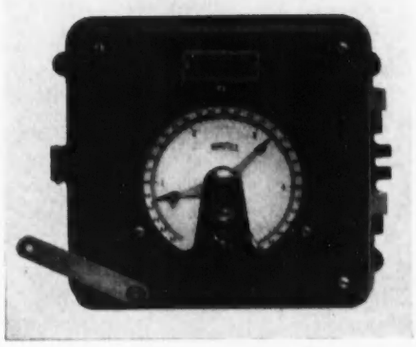


Fig. 2—"Automatic" Cycle Stop Type Contactor, which may be set by an adjusting knob to the elapsed time required

scale ranges for this type of unit range from 1 min. to 120 min., and each scale division may range from 1 sec. to 30 sec. It is possible to set the high contact arm for any desired elapsed time within the full-scale range of the dial, and this setting can be made to a scale division or closer.

Bijur
System of Central Lubrication

CLEAN oil in predetermined quantities is supplied simultaneously to all bearings on a machine by the Bijur system of central lubrication developed by the Bijur Lubricating Corporation, 250 W. 54th St., New York, N. Y. A single depression of the pump lever once every three or four hours is all that is required to lubricate every bearing on the machine. Control of the oil flow is accomplished without the use of moving parts. Oils as light as kerosene or as heavy as clear transmission oil can be handled.

The pump and reservoir comprise

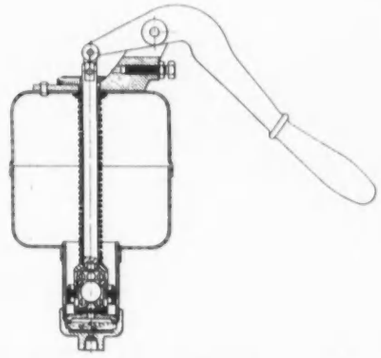


Fig. 1—Bijur Hand-Operated Pump and Reservoir for industrial lubrication systems. Cylinders trapping 1 or 2 cu.in. of oil per stroke are built

a self-contained unit and may be located at any convenient place on the machine. Depression of the pump handle loads the cylinder shown in Fig. 1 with a predetermined quantity of oil, and release of the handle places this oil under a pressure of approximately 50 lb. per sq.in. As the lines are always maintained full of oil, flow begins immediately from each drip plug, irrespective of its distance from, or height in relation to, the reservoir. The drip plugs apportion the measured charge of oil delivered by the pump in accordance with their respective flow capacities. Seven separate flow rates from approximately $\frac{5}{8}$ of a drop per min. to 46 drops per min. are available for the lubrication requirements of various bearings.

When the pump is operated, the

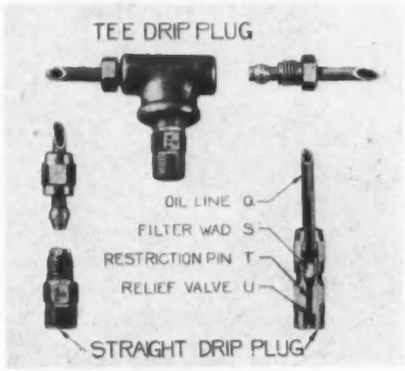


Fig. 2—Construction of Bijur T-head drip plug

piston is raised against the downward pressure of the coil spring. During the upstroke, a charge of oil is drawn through the oil ports in the piston and around the ball into the space under the piston. When pressure is removed from the operating lever, the coil spring forces the piston down, and the upward rush of oil lifts the ball valve to its seat in the piston. The measured charge of oil trapped in the cylinder below the piston is then forced into the lines by the pressure of the spring. The piston stroke is adjustable by means of a stop screw and lock nut, so that any predetermined amount of oil may be fed into the lines. A dense felt filter disk prevents dirt or solid matter from entering the system. The pump and reservoir units are available in three sizes: 1-qt. reservoir with a 1-cu.in. pump, another 1-qt. reservoir with a 2-cu.in. pump, and a 2-qt. reservoir with a 2-cu.in. pump.

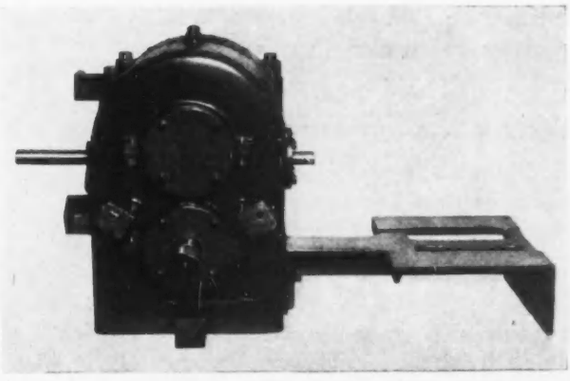
Drip plugs used in the system, as shown in Fig. 2, contain three elements: a felt filter wad, a restriction passage containing a pin, and a relief valve. The restriction pin nearly fills the cylindrical passage in which it lies. Clearance between the pin and the passage wall determines the rate of flow of the oil. The relief valve is normally held closed by a spring, but opens under a pressure of approximately 5 lb. per sq.in., allowing oil to flow. When the flow ceases, the pressure drops to less than 5 lb. per in., and the valve closes, preventing drip, and keeping the lines full of oil. The valve is faced with a flexible material that eliminates leakage. This method of delivering oil permits the lubricant to build up a film on the bearing surface, instead of forcing it out of the bearing through the slack side.

Drip plugs are made in three styles: (a) straight or terminal types to be screwed directly into the bearing; (b) tee-head drip plugs made with two, three, and four outlets for use where lines are to be carried to points beyond the bearings which they lubricate, and (c) junction drip plugs to be used in connection with tee-head drip plugs, or with Bijur junctions.

Gears and Forgings
Two-Speed Stoker Drive

STOKER installations requiring only two speeds can be taken care of with the two-speed gear reduction unit announced by Gears and Forgings, Inc., Cleveland, Ohio. This gear unit is fully inclosed and is of the dust-proof, split housing type. The two speeds are controlled outside of the unit by the conventional ball and socket shift lever, which operates a double-jaw clutch. This clutch is of the 10-jaw type, facilitating prompt engagement at any speed or load.

Gears and shafts of this reducer are of forged nickel steel, heat treated, ground, and hardened. The worm gear is of S.A.E. 65 bronze. All principal bearings are of the antifriction type. Through the arrangement of the gears, the oil level is



Two-Speed Stoker Drive Unit built by Gears and Forgings, Inc.

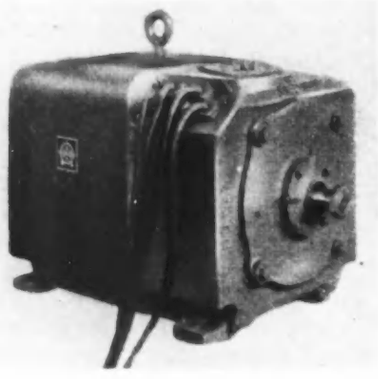
NEW MATERIALS AND PARTS

maintained below the input and output shafts, thus insuring against the possibility of oil leakage. All gears and bearings are afforded adequate lubrication by a simple splash system.

Each unit receives a laboratory running test and is furnished in dark green machine enamel, which is both heat and moisture resisting.

Reliance Explosion-Proof Mine Motor

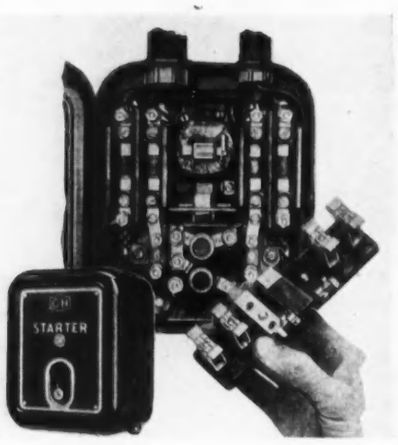
EXPLOSION proof characteristics are featured in the enclosed motor built by The Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio, for use on coal mining machinery. The motor is so constructed that even if an explosive mixture of natural gas and air should leak inside, ignite, and explode, the motor will withstand the



explosion and not communicate sparks or flame to the outer air. These motors are built in sizes required for driving coal loaders, coal cutters, and other coal mining machinery.

Cutler-Hammer "Twin Break" Magnetic Contactor

THE entire line of Type AAA automatic starters for small a.c. motors has been redesigned by Cutler-Hammer, Inc., 80 12th St., Milwaukee, Wis., to incorporate a "Twin Break" magnetic contactor. This contactor provides for reducing the arc voltage by half, and the Thermoplax arc pockets, by reducing the air content around the contacts, actually prevent



the formation of a destructive arc.

A magnetic latch has been added to prevent accidental closure of the contacts, if the starter is accidentally bumped or tilted. Before the contacts will close, the latch must be drawn aside by the operating magnet. The contactor is made in three- and four-pole types, the maximum rating for two- or three-phase circuits being 3 hp., 110 volts; 5 hp., 220 volts, and 7½ hp., 440 or 550 volts.

"Ruselite" Light Aluminum Alloy

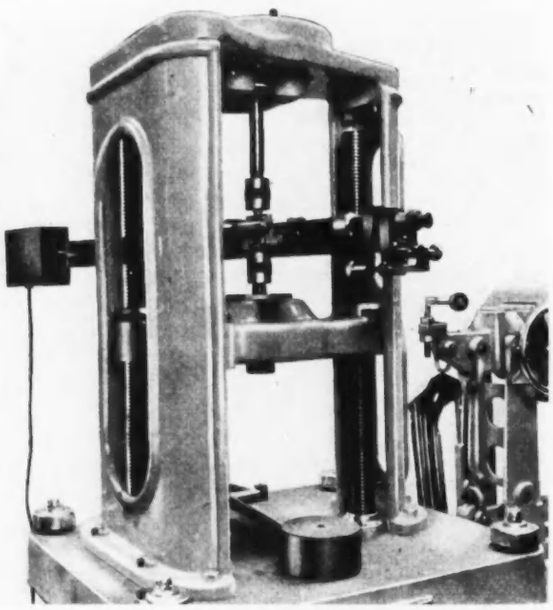
CHROMIUM and molybdenum are constituents of the light aluminum alloy announced by the Ruselite Corporation, 291 Fourth St., Milwaukee, Wis. The metal when die-cast has a tensile strength of 30,000 lb. per sq.in., and an elongation of between 5 or 6 per cent in 2 in. In addition, "Ruselite" is capable of taking a fine finish when polished, this finish closely resembling chromium plating and requiring no plating.

In sheet form, Ruselite has a tensile strength of 42,000 lb. per sq.in., as compared with the aluminum-copper alloys having a tensile strength of about 40,000 lb. per sq.in. in the hard state. Also, when annealed Ruselite has a drop in tensile strength of only about 1,000 to 2,000 lb., whereas the aluminum-copper alloys may drop from 10,000 to 15,000 lb.

In the form of die castings, the material resists salt atmospheres and mild acids. It is being used as hardware for equipment where eye appeal is one of the distinct selling points.

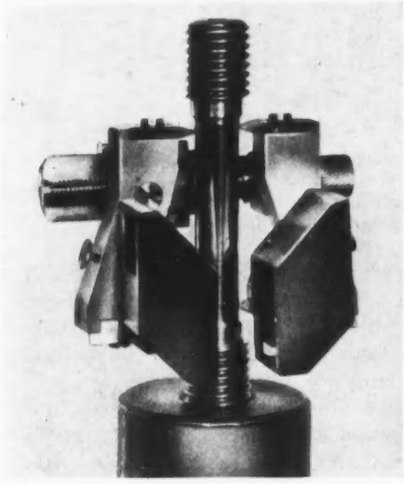
Riehle-Sayre Mirror Extensometer

ROUTINE testing of 1-in. tension test specimens of 2-in. gage lengths can be done with the "Riehle-Sayre" mirror extensometer announced by Riehle Bros. Testing Machine Company, 1424 North Ninth St., Philadelphia, Pa. It permits a semi-production basis of the reading of high-precision extensometer measurements, where the unit strain at the proportional limit is often below one part in a thousand. By the use of a system of four prisms two ends are gained: First, elongations on both sides of the specimen are averaged automatically, and second, any movement or vibration of the specimen is automatically cared for. Optically, the instrument consists of a telescope with a horizontal cross-bar supported on a bracket, a system of four prism mirrors on a light weight extensometer attached to the test specimen,



Riehle-Sayre Mirror Extensometer equipment set up on a test specimen

and an illuminated scale supported at a fixed distance from the test specimen on the opposite end of the bracket from the telescope. The upper two prisms are fixed in position during the test and the lower



A system of four prism mirrors is attached to the Riehle-Sayre Mirror Extensometer

prisms are supported so that they tilt as the test bar elongates. Readings may be taken directly to 1 part in 100,000 on a 2-in. gage length and may be estimated to a fraction of that figure.

Trabon Progressive Lubricating System

PROGRESSIVE lubrication of one feeder after another, until the entire circuit has been completed, is the feature of the Trabon progressive lubricating system developed by the Lubricating Equipment Company, 31 Brady St., Detroit, Mich. The line is always filled with lubricant, but is only under pressure when the pump is operated. As soon as fresh lubricant is started through the line, the first feeder expels its quantity to the bearing. Then the lubricant is allowed to pass the first feeder and proceed to the other feeders in turn, until the circuit around to the pump is completed. But the lubricant cannot pass the first feeder or any other feeder in the line until that feeder expels the lubricant to the bearing. If any trouble develops in the bearings, feeders, or anywhere in the line, no lubricant can be forced through the circuit, thus giving a positive and immediate indication to the operator that something is wrong.

When the lubricant makes a complete circuit, an indicator located at the pump shows that the circuit has been completed. On the next shot, the lubricant is sent through the line in the opposite direction. A simple reversing mechanism at the pump operates to reverse the flow of lubricant. This may be accomplished either automatically or by hand. The line is thus kept clean by reversing the lubricant flow. Sufficient pressure can be developed at the pump to overcome resistance at the bearings, in the feeders, and in the line. Pressures up to 4,000 lb. can be delivered, if necessary. The pump may be filled through a grease fitting at the bottom by means of any portable tank or gun, or with a scoop by removing the covers.

Reference to Figs. 2, 3 and 4 will show the action of the Trabon feeder. It is made from solid steel with a steel cap on each end. The size of the main floating piston and chamber determines the amount of lubricant to be shot to the bearing each time. Capacities range from 0.05 to 1.50 cu.in. The lubricant comes in at the left of Fig. 2 and pushes the dumb bell pistons *B* and *C* to the right. This uncovers port 4 and allows the lubricant to flow into the main chamber. The main piston *D* is moved to the right, which pushes the lubricant lying to the right of the piston *D* out through port 5, and through port 6 into the bearing. When main piston *D* has moved to the extreme position as in Fig. 4, port 3 is open and lubricant from the main line, coming through port 4, passes through port 3 and out port 2 into the main line again and the next feeder. For the next shot of lubri-

Fig. 1—Trabon No. 2 Hand Pump with hand reversing mechanism

cant, the operation of the feeder is reversed, but the sequence of movements is exactly the same.

Lubricants varying from heavy machine oil to greases can be used in the Trabon pump. Capacities of these pumps range from 2 to 12 lbs. A motor-driven pump can be furnished, together with the necessary electric control and time clocks.

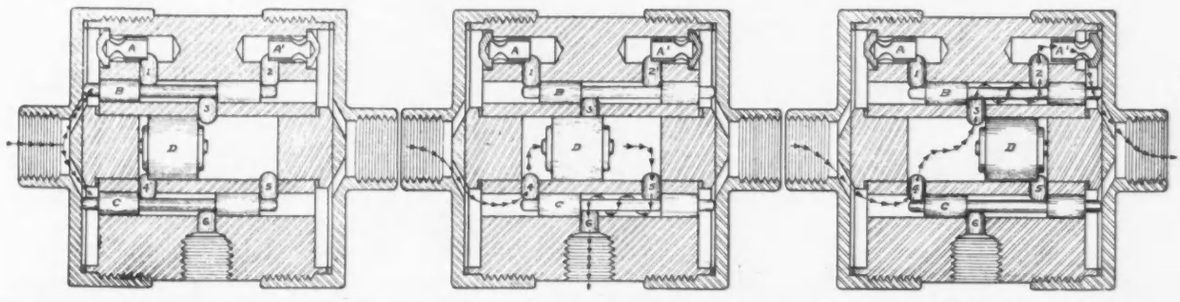


Fig. 2—Feeder in neutral position and filled with lubricant from the last shot. Fig. 3—Feeder with both dumb-bell pistons moved to the right and piston ready to shoot the lubricant into the bearing. Fig. 4—Lubricant has been shot into the bearing and that from the main line is now passing to the next feeder

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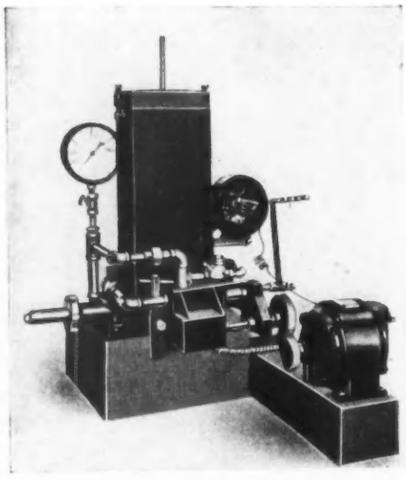
Bornes Universal Lubricant Compressor

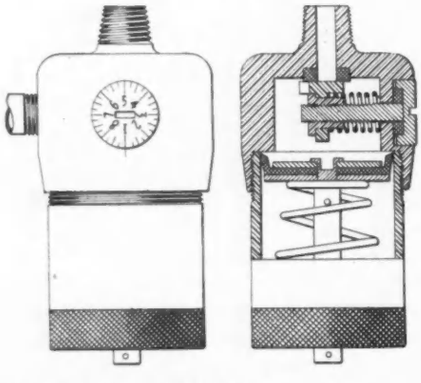
OILS of any viscosity or greases of almost any consistency can be handled by means of the Bornes universal compressor developed by the Borne Scrymser Company, 17 Battery Place, New York, N. Y. This



Bornes Universal Lubricant Compressor in the motor-driven model

compressor is available in two sizes, 4 and 6 qts., respectively, and may be operated by hand, belt drive, or motor drive. In place of a pump handle, the square transmission box at the lower front of the equipment shown can be bolted in any one of four positions for belt or motor drive.

When piped to a machine, the compressor will deliver to the lubricators an even supply of clean lubricant under the required pressure. This lubricant is not delivered continuously, but is subject to the will of the operator. When the compressor is started it fills the lubricators and then bypasses the lubricant into another cylinder. This causes the belt shifter to throw the belt to the loose pulley. As the lubricant is consumed, a pressure adjusting screw can be turned and the belt is again carried over to tight pulley and the booster set in motion. In place of the belt shifting fork, a contact breaker can be supplied to open and close the contact when an electric motor is specified as the drive.



Bornes Universal Lubricator for oils and greases

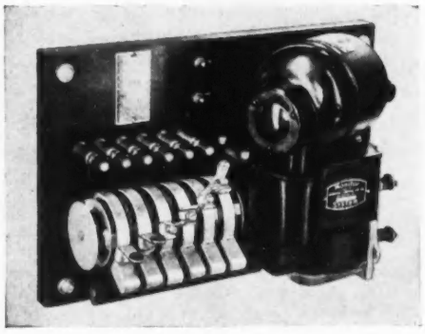
Armstrong L-K Cork Board

A LIGHT-WEIGHT, low-temperature insulating material of low conductivity, termed L-K cork board, has been announced by the Armstrong Cork & Insulation Company, Lancaster, Pa. It is adaptable to refrigerant work where weight is a factor, such as in railway cars and trucks. It weighs 0.6 lb. per board ft., as compared with 0.8 to 0.9 lb. for standard insulating cork. Conductivity is 0.265 B.t.u. (per sq.in. per hour, per $\frac{1}{8}$ in., per deg. diff. in temp. at 60 deg.) as compared with 0.300 for standard grades. The material is made of selected granules of cork packed into board form with a suitable binder.

"Monitor" Work-Cycle Timer

TIMING requirements of any electrically controlled work cycle can be met with the control device announced by the Monitor Controller Company, Baltimore, Md. This work-cycle timer will start, stop, accelerate, decelerate, reverse, heat, cool, open, close, raise, lower or perform any other operations in sequence and at definite time intervals that may be easily and accurately adjusted. The most important characteristic of the device is that it can be reset instantly at the starting point at any time during, or after, completion of the cycle.

In a given timer unit, all current-carrying switches are electrically connected to the pivoted side. Each individual switch consists of a rotatable disk carrying an adjustable



"Monitor" Work-Cycle Timer, which can be arranged for any sequence of operations to be performed at definite time intervals

contact point and a post fixed on the panel and connected directly to the circuit to be controlled. There are as many of these little switches as there are circuits in the sequence. The rotatable disks are mounted loosely on a sleeve, which is carried on a revolving hollow shaft. Each such rotatable disk is placed between two rotating disks keyed to the shaft. These rotating disks are equipped with carbon blocks that bear lightly against the switch disks.

A constant-speed electric motor drives the rotating hollow shaft. Through the center of the shaft extends a clutch rod that can be moved by the action of a powerful magnet. When the magnet is excited, the clutch rod is pulled to the right, and all the disks are pressed together. Then the switches rotate, being driven through friction by the driving disks. Rotation of each switch continues until it closes on its stationary contact post. From that time on, it simply slips between its driving disks. When the magnet is released, the pressure is removed from the disks and the reset weights cause all the switch disks to drop back to the normal rest position.

"Calite F" Heat-Resistant Alloy

A nickel-chromium alloy that possesses the quality of casting in comparatively thin sections has been recently announced by the Calorizing Company, Wilkinsburg Station, Pittsburgh, Pa. It is known as "Calite F" and is particularly recommended for thin-wall carburizing boxes, annealing pans, enameling racks, and other furnace fixtures. The material has

NEW MATERIALS AND PARTS

a maximum safe working temperature of 1,900 deg. F., at which the safe load is 1,250 lb. per square inch.

When cast in the form of a box, the sections may be $\frac{3}{16}$ in. to $\frac{1}{4}$ in. in thickness, so that the total weight compares favorably with sheet containers, but has the rigidity of a casting.

Smith Small Speed Reducers

SMALL reduction gears for use with $\frac{1}{8}$-hp. motors have been placed on the market by Winfield H. Smith, Inc., Springville, N. Y., in the Nos. 2B and 3B types. These models employ anti-friction bearings throughout. Specially designed ball bearings eliminate the need for stuffing boxes.

The model 2B can be furnished with ratios of 48 to 1 and 30 to 1, and the No. 3B in ratios of 20 to 1, 10 to 1, and 5 to 1.

Another model is the No. 2DB,

Smith No. 2B Reduction Gear for use with ⅛-hp. motors

which can be furnished with ratios of 400 to 1, 200 to 1, and 100 to 1. It has a double worm gear drive, capable of transmitting a torque of 150 in. lb. Radial thrust ball bearings are furnished on the high-speed shaft, ball thrust bearings on the intermediate shaft, and plain bearings on the slow-speed shaft.

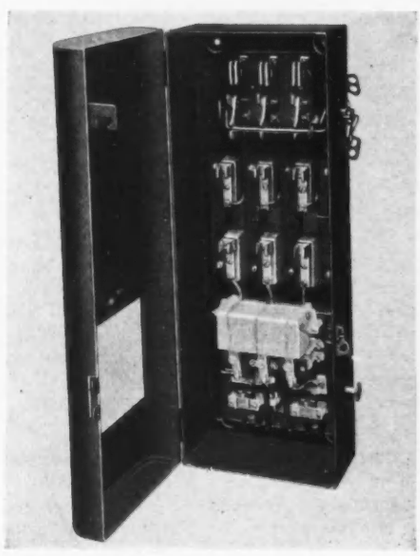
"Aremite" High-Strength Iron

AN electric furnace iron has been introduced to the trade under the name of "Aremite" by Robbins & Myers Sales, Inc., Springfield, Ohio. This iron has a tensile strength that can be varied between 30,000 and 50,000 lb. per sq.in., depending upon the hardness desired. At the lower limit, a Brinell hardness of 165 is attained, with corresponding ease of machinability. The microstructure of this material is similar to that of malleable iron, the distribution of graphite particles being quite fine.

"Aremite" has been successfully substituted for many castings formerly made of cast steel or malleable iron, at a lower cost than either, and at about six times the normal speed of delivery of malleable castings.

Square D A.C. Contactors

THREE a.c. contactors for across-the-line service have been placed on the market by the Industrial Controller Division of the Square D Company, Milwaukee, Wis. These starters are known as Classes 8532K, 8536K, and 8537K. They consist of an automatic starter providing low voltage and overload protection, and a quick-make and quick-break knife switch mounted in the same cabinet. These switches are provided with arc suppressors, which increase their breaking capacity at the higher voltages. The switches will break the stalled rotor current of motors within the ratings of the starters. An interlock is provided which prevents opening the door of the cabinet unless the switch is in the "off" position.

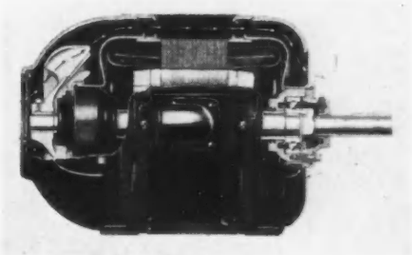


Square D Class 8532 K Fusible A.C. Contractor for across-the-line service

These starters can be supplied either not fusible or fusible for branch line protection. They may be controlled by push buttons or automatic pilot switches, such as pressure and float switches, and thermostats.

General Electric Type K Totally-Inclosed Fan-Cooled Motors

A LINE of dust-tight, totally inclosed, fan-cooled induction motors has been developed by the General Electric Company, Schnectady, N. Y. These motors are equipped with ball bearings, in convenient "cartridge" housings. This line provides a totally inclosed motor of the same mounting dimensions, rating for rating, as the



standard open-type, General Electric, horizontal, general-purpose motor, from $\frac{3}{4}$ to 50 hp. in popular speeds.

Size and weight are minimized in these motors. The single ventilating fan is located outside the motor enclosure on a short shaft extension opposite from the pulley end. A double frame is used, providing air passages for the ventilating air.

The type is indorsed by the Underwriters' Laboratories for hazardous dust conditions specified as Class 2 in the National Electric Code.

"Perfect" Oil and Grease Retainers

A self-contained, self-aligning device for sealing the lubricant in any machinery application, in which oil or grease are used, has been placed on the market by the Chicago Rawhide Manufacturing Company, 1301 Elston Ave., Chicago, Ill., under the

REVIEW OF RECENT PATENTS

trade name of "Perfect" oil and grease retainer. It is offered as a compact, self-contained unit, with the stamped steel parts, leather packing member, and spring completely assembled. Installation consists merely of press-fitting into a simple machined recess in hub, housing, or bearing retainer. When furnished on

"Perfect" Oil and Grease Retainer cut away to show the coil spring, which presses the leather firmly against the shaft

water pumps and other water sealing applications, the retainers are furnished with all metal parts plated and equipped with special leathers.

Leather of different tannages is specified for varying applications. Permanent contact between the packing member and the shaft, spindle, or hub is obtained by a coil spring. Standard sizes are available for shafts from ½ to 3½ in. in diameter.

PUBLICATIONS

FOR THE ENGINEERS' LIBRARY

CHAIN DRIVES IN STOCK. The Diamond Chain & Manufacturing Co., Indianapolis, Ind., has issued a 64-page book No. 78 on stock chain drives intended for a majority of motor and countershaft applications requiring from ¼ to 75 hp., in ratios up to 8.4 to 1, and with motor speeds of 1,800 r.p.m. Complete tables, applications, and advantages are incorporated.

CHAINS, SILENT AND ROLLER. The Union Chain & Manufacturing Co., Sandusky, Ohio, has issued a 124-page catalog on silent and roller chain, containing complete specifications and engineering data for design purposes, and also engineering data on sprockets and chain attachments for special purposes.

DIE CASTINGS. The Aluminum Company of America, Pittsburgh, Pa., has issued a bulletin "Alcoa Aluminum Die Castings," discussing the various properties of these products, showing representative examples, and discussing the alloys and design principles.

FINISHES. The Norfolk Paint & Varnish Co., Norfolk Downs, Mass., has published a booklet containing solutions to various painting problems, among which are many in the field of product design and industrial requirements.

GEARS, INVOLUTE. The Fellows Gear Shaper Co., Springfield, Vt., has available a fifth edition of the "Involute Gear," which has been completely revised and contains considerable new material. It is a fundamental treatise dealing with the involute curve and its application to gear teeth.

GENERAL ELECTRIC PUBLICATIONS. The General Electric Co., Schenectady, N. Y., has issued bulletins as follows: GEA-38B, superseding 38A, on "D.C. Crane and Hoist Motors Type CO-1820"; GEA-1277, superseding 61512, on "Fractional-Horsepower Motors and Motor Parts for A.C. and D.C. Operation"; GEA-1303A, superseding 1303, on "Squirrel-Cage Induction Motors."

HEAT RESISTING ALLOYS. The Calorizing Company, Wilkinsburg Station, Pittsburgh, Pa., recently issued a bulletin on "Calite" alloys, a group of heat enduring materials of the nickel-chromium series for temperatures up to 2,000 deg. F. Numerous photographs are used to show particular application of the alloys, particularly furnace and petroleum still parts. Data on the corrosion resistance of the Calite-Nirosta alloys are also given.

MOTORS. The Master Electric Co., Dayton, Ohio, has added Data Book Section 202 on single-phase motors of the repulsion-induction type for a.c. circuits. The type RA motors are available from $\frac{1}{30}$- to 5-hp. sizes, inclusive.

MOTORS. Reliance Electric & Engineering Co., Cleveland, Ohio, has issued Bulletin No. 107 on its fully inclosed, fan-cooled induction motors, Type AA, Form F, with ball bearings, for two- and three-phase, a.c. circuits.

MOTORS, TOTALLY INCLOSED. The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has issued Leaflet 2124 on its type "ARZ" totally enclosed, fan-cooled motor, showing the construction of this type, which is particularly suitable for very dirty locations.

NICKEL ALLOY STEEL FORGINGS. The International Nickel Co., Inc., 67 Wall St., New York, N. Y., has available No. 17 of its Nickel Steel Data and Application series entitled, "Nickel Alloy Steel Forgings," giving a comparison of normalized nickel steel and carbon-steel forgings, a list of uses, analyses, heat-treatment, and properties.

POWER TRANSMISSON EQUIPMENT. The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has issued two publications pertaining to mechanical power transmission. The first is entitled "Westinghouse-Nuttall Flexible Couplings" and contains complete descriptions, capacities, dimensions, and weights of the different types. It is known as Circular No. 1887. Circular No. 1891, entitled "Westinghouse-Nuttall Speed Reducers, Types SVR, DVR, and DVRA," contains full information about application, construction, ratings, and dimensions.

PYROMETERS. The Brown Instrument Co., Philadelphia, Pa., is the publisher of Catalog No. 15A on its indicating, recording and controlling pyrometers, containing 104 pages with 141 illustrations, many of which are in colors. A comprehensive résumé of the theory and practice of applied pyrometry is presented, together with descriptions and illustrations of all instruments, and allied equipment.

TEMPERATURE CONTROL DEVICES, AUTOMATIC. The Brown Instrument Co., Philadelphia, Pa., now has available a booklet, "The Era of Automatic Control," which is mainly made up of pictures showing automatic control apparatus applied in a wide range of industries. Types of controls are also illustrated.

PATENTS

Patent 1,772,010 has been issued to Lloyd Livings, Peoria, Ill., on a lubricating device incorporating a ball check valve and an air passage to force lubricant through a small opening and into the bearing.

An engine piston covered by patent 1,772,103 issued to Charles A. Marien, St. Louis, Mo., has suitable formations on that part of its surface subjected to greatest expansion, these formations being adapted to wear to provide the proper clearance for working conditions.

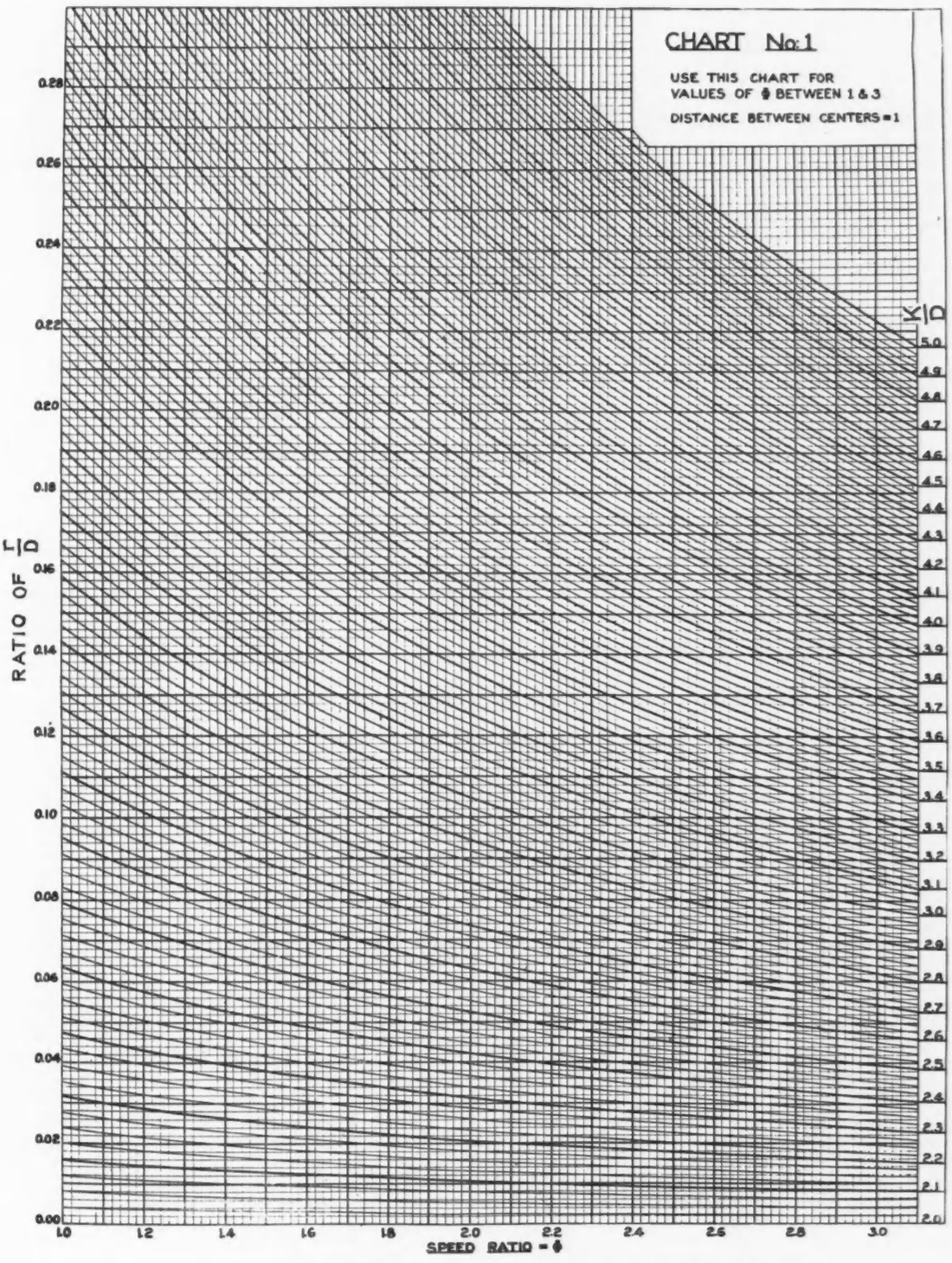
Harold C. Harvey and Hubert L. Becher, of Trenton, N. J., were granted patent 1,763,563 on a board composed of two layers of compressed fiber joined to prevent warping.

Patent 1,775,105 has been granted to Paul A. Ketchpel and Nathan M. Lower, Pittsburgh, on a hydraulic brake for motor vehicles, consisting of a vacuum motor for compressing the fluid, the motor being connected to the suction chamber of the engine.

A coupling for relatively movable members is covered by patent 1,777,129, granted to Walter C. Robbins, assignor to Houde Engineering Corporation, and comprising a housing having a side opening, a ball socket in the housing, a ball having a neck projecting through the opening, a cup-shaped elastic closure for the neck, and a metal cap receiving the closure and provided on its convex side with a projecting fulcrum, which engages with the arm and forms a rocking bearing between the cap and arm.

Charts for Stepped Cone Pulley Drives

Refer to page 424 of the September, 1930, number of *Product Engineering* for a detailed description of these charts.



For geometric progression of speeds, find the ratio of the highest to the lowest speed. Abstract the $(n-1)$ root of this ratio, n being the number of speeds desired. This will be the speed ratio factor. Calculate the smallest speed ratio, that is, the ratio of the smallest speed on the driven pulley divided by the speed of the countershaft. Successively, multiply this speed ratio by the speed ratio factor calculated above, thus obtaining the speed ratio for each step.

Choose the diameter of the smallest step on the cone pulley, and divide this diameter by the shaft-centers distance. With this quantity as ordinate, and the corresponding speed ratio as abscissa, locate the curved diagonal of constant

Contributed by Wilfrid E. Johnson, Oregon State College

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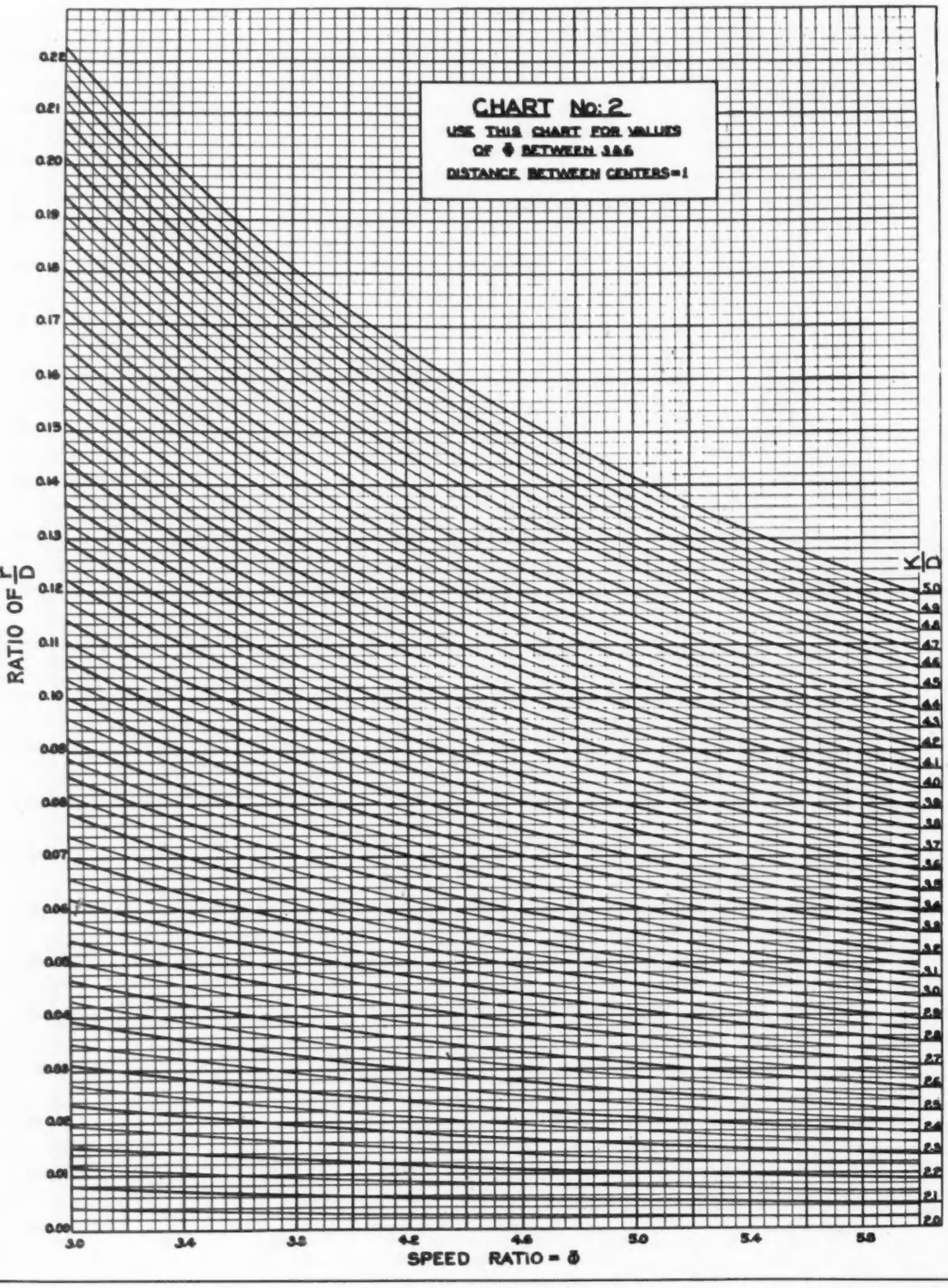

belt length. The ordinates corresponding to the intersections between this curve and the desired speed ratios will be the values of the corresponding radii of the steps of the cone pulley divided by D, the distance between shafts. Multiply by D to obtain the radius.

The length of belt required will be obtained by multiplying the value of K/D by D.

All speed ratios must be expressed in numbers greater than unity. If the speed ratio is less than unity, the reciprocal should be taken. The quantity r will then be the radius of a step on the driving cone instead of driven cone.

Extra copies of these charts are available upon request

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